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EDITORIAL NOTES.

THE Annual Report of the Council of the Geological Society of London for 1919, presented at the Anniversary Meeting on February 20, 1920, does not contain any very striking features. It is pleasing to observe that there has been a large increase in the number of new Fellows elected, 81 as against 32 in 1918, and this in spite of the increase of the annual contribution from two to three guineas for Fellows elected after November 1, 1919. During the year it was decided to admit women to the Society, but so far only fourteen have availed themselves of the privilege. The list of medals and awards has already appeared in the Magazine. The publication of the Quarterly Journal has made up some of the leeway, and is now only one year behind date, but the position of the annual index of geological literature seems hopeless, the last issue being that for the year 1912. The continuation of this most useful work seems to be largely a matter of funds, and it is satisfactory to note that the Royal Society has made a grant of £100 towards the publication of the volume for 1913, which it is hoped will soon appear, although its progress has naturally been delayed by the resignation of the Librarian, Mr. C. P. Chatwin. The vacancy thus created has been filled up by the appointment of Captain A. Greig, formerly Assistant Librarian. It is disquieting to find that the estimates anticipate a deficiency of £300 on the working of the Society for the coming year, and geologists who have not yet done so should apply for admission as Fellows, and thus help this, the leading geological society of the world, to maintain unimpaired its great work in the interests of the science.

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AT the annual meeting of the Geological Society of America, held at Boston, officers for the year were elected as follows: President, I. C. White, Morgantown, W. Va.; First Vice-President, G. P. Merrill, Washington, D.C.; Second Vice-President, W. G. Miller, Toronto; Third Vice-President, F. B. Loomis, Amherst, Mass. Many papers were read, and a discussion on the teaching of geology attracted much attention. It is an interesting fact that during the meeting two new societies were formed, with the full approval and support of the parent organization. The Mineralogical Society, formed at Cambridge, Mass., elected as its first President E. H. Kraus, of Ann Arbor, and as Secretary H. P Whitlock, of the American

Museum of Natural History, New York. The other new Society, the Association of Applied Geologists, should do much to fill up the gap that now exists between pure geology and the branches of engineering and other sciences and arts bearing upon the exploitation of our mineral resources. We wish both these new societies a long and prosperous career.

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Many old Cambridge geologists both at home and abroad will be glad to hear that the Sedgwick Club has entered on a career of renewed activity after the inevitable period of eclipse, due to the War. In the autumn of 1914 the few remaining ordinary members held a meeting at which they appointed a committee, mostly composed of members of the teaching staff, under the chairmanship of the Woodwardian Professor, to hold office till the end of the War, with powers to elect ordinary members. Last May term this committee exercised its powers by nominating sufficient new members to form a quorum, and then extinguished itself. After this matters proceeded in the ordinary way, and the Club is now as flourishing as ever, or even more so, as shown by the following communiqué received from an official source: "The Sedgwick Club has formed a committee for directing and carrying out a detailed study of the Pleistocene and Holocene deposits of the Cambridge district with special reference to questions connected with Ancient Man in Britain. Some years ago a similar committee of the Club studied the distribution of the glacial boulders in the district. The enthusiasm with which that work was carried out, and the interesting results obtained, recorded in a paper by Messrs. Rastall and Romanes (Quart. Journ. Geol. Soc., vol. lxv, 1909, pp. 246–65) augur well for the success of the present undertaking."

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With the opening of Parliament the question of the nationalization of mines has again reached an acute stage, and appears likely to be in the forefront of politics for some time to come. In the debate on the Address the Prime Minister spoke words of solid wisdom, and foreshadowed most determined opposition on the part of the Government to the projects for bureaucratic control of our greatest industry. We have already drawn attention in these columns to the fallacies of the prevailing Fabian arguments in support of nationalization of coal-mines. It is currently reported that labour witnesses before the Board of Trade Committee on non-ferrous mining have spoken in favour of nationalization as a remedy for the troubles of their own particular branch. Everything that has been urged against it in the case of coal-mines applies with even greater force to metalliferous mines, and there is here an added argument of the greatest cogency. It is well-known to every one at all conversant with the subject that metalliferous mining, especially

non-ferrous, offers much greater uncertainties than coal-mining, and, indeed, is almost always inevitably in the nature of a gamble. This is simply a matter of geology, and it is unnecessary to labour the point. Now it is manifestly impossible for the State to enter upon such a hazardous type of speculation with the public funds as capital; even the most academic economist and the most theoretical socialist must recognize this fact, and the inevitable result of the interference of the State and control by a Government department would be the total stoppage of enterprise and development in this direction and a complete cessation of any production of non-ferrous metals in this country. Such a state of affairs is unthinkable.

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THE Board of Trade Committee on non-ferrous metalliferous mines has now completed the taking of evidence, and a report is being prepared which it is hoped will be ready for presentation in the course of a few weeks. At the later sittings of the Committee some interesting evidence was given concerning lead, zinc, and barytes. With regard to the last-named product Col. J. V. Ramsden, of the Shropshire Mines, Ltd., pointed out the need for improved methods of preparation, and also for protection against the dumping of cheap foreign material, if the barytes industry in this country is to be preserved. Mr. J. Mitchell, of Wanlockhead, described the scheme for a very long deep-level gravity tunnel for the drainage of the Wanlockhead–Leadhills district. Much evidence was given concerning the present position of the lead-zinc mining industry in the North of England. It was stated that the Ashover Mines in Derbyshire are now worked almost exclusively for fluor-spar, for which there is a good demand as a flux in metallurgical work. It appears that in many localities the visible supplies of ore are now approaching exhaustion, and Professor Louis considered that the allocation of national funds to investigation of the Melmerby Scar Limestone would be justified, as in his opinion this offers the most promising prospects. In this connexion it may perhaps be allowable to point out that purely geological considerations are of great importance. If the ore came from below there should be a tendency for it to accumulate under such an impervious rock as the Whin Sill. Now it is well known that the sill is transgressive, occurring in different places at very various stratigraphical horizons. Hence the most likely place for ore would seem to be in places where the Whin Sill rests on a well-marked bed of limestone, if such can be found. This evidently needs a close and detailed study of local stratigraphy.

ORIGINAL ARTICLES.

On an Inverted Mass of Upper Cretaceous Strata near Leighton Buzzard, Bedfordshire; and on an Overlap of the Upper Gault in that Neighbourhood.

By F. L. Kitchin, M.A., Ph.D., and J. Pringle, F.G.S.

(*Concluded from p. 62.*)

C. Identification of the Strata between the "Silver-sands" and the Inverted Mass in Mr. Harris's Pit.

An examination of the sections at and near Shenley Hill, described above, thus provides the means for a complete interpretation of the puzzling stratigraphical relationships seen in Harris's Pit. The inverted Upper Gault and basal Cenomanian limestone masses have already been identified zonally: the sand-beds distinguished as G and F by Mr. Lamplugh and those parts of his bed D which are not of Cenomanian age remain to be correlated.

The well-bedded, impure, fine sand (G), overlying the "silver-sands", may be recognized as a thin and probably denuded representative of the 6 ft. bed of streaked and carbonaceous sand underlying the *tardefurcata* bed at Miletree Farm (No. 8). The overlying stratum F, a coarser and less well-bedded greenish clayey sand, is here and there rather abruptly separated from bed G, but in other places forms an upward continuation of it. The two may be considered to form part of one deposit. The coarser sand of F occurs as small shallow banks, which are discontinuous in places; when it is absent the next higher bed, forming part of bed D of Mr. Lamplugh (the part designated D_1 in Fig. 2), is then in contact with bed G, which in one place where such a relationship was seen was reduced to 4 inches in thickness.

The sandy beds G and F, of pre-*tardefurcata* age, form the highest member of the Lower Greensand present in this section. They are overlain immediately by the unconformable basal bed of the Upper Gault, with which we have become familiar in neighbouring sections. For convenience we refer to this bed at Harris's Pit as D_1. We have seen that its development, wherever it is normally overlain by the Upper Gault Clay, is that of a continuous basal bed of mixed composition, variable in thickness, and with uneven lower surface. At Harris's Pit it shows less continuity and greater irregularity in its mode of occurrence. The clay which normally overlies it, with the exception perhaps of a few little isolated traces, had been locally removed by denudation before the overturned mass of strata became deposited in this place. The remnants of the basal bed itself, which formed the floor upon which the inverted strata came to rest, may owe some of their present irregularities to the same denudation; but the confused aspect of the bed is doubtless to be ascribed in

considerable measure to the stresses and disturbances set up by the weight of the overlying transported mass.

An isolated lenticular portion of this crushed floor, distinguished as D_1 in our illustration, shows only one aspect of the manner in which the bed occurs. The stratum is sometimes continuous for a distance of several yards, occupying most of the space between the "silver-sands" and the inverted Gault above. It then shows the closest resemblance to its normal development, as seen, for instance, at Garside's Pit or at Miletree Farm. Frequently, however, softer portions of the bed dwindle laterally into streaks, and the relations of the deposit to the underlying sand, F, show here and there considerable confusion. It is possible that at the time of the transgression the sandy floor may have become locally churned up and its materials redeposited in close association with the other constituents of bed D_1; but the later addition of the great weight of the superincumbent transported mass of strata, even leaving out of account the added pressure of glacial ice, seems to us to explain sufficiently most of the irregularities in these relatively soft strata. Some of the surfaces now marked by the presence of secondary limonite-segregations, as in the upper part of bed F, doubtless originated by minor disruptions caused at the same time.

Little need be added regarding the lithological characters of bed D_1. These are variable, just as at the other localities where this basement-bed occurs. In places the coarser constituents, that is to say the rounded pebbles and grit-grains, the angular or sub-angular platy fragments of ironstone, and the polished hollow pebbles of ironstone, are segregated so that such portions of the rock almost form a breccia. Other parts show a finer and more even composition, so that the yellowish and brown sandy or gritty clay-matrix then contains few of the ironstone-fragments. Small pockets of greenish and brownish clay also occur. We have already noted the presence in one place of a flat claystone nodule similar to those forming a layer in the passage-bed (of *tardefurcata* horizon) north of Miletree Farm. A few small white calcareous nodules have also been seen, just as in this basal Upper Gault at other localities. In one part of the topmost layer, where the limonite-band, C, dipping down slightly for a short distance, happened to occupy a surface of weakness just below the top of the bed instead of above it, we noticed that the limy nodules were flattened. The matrix in this patch, immediately in contact with the overturned Gault, was horizontally laminar and fissile, owing to a deformation resulting from pressure.

We can throw little light on the palæontological characters of this Upper Gault basement-bed. It is relatively unfossiliferous, and we have done no more than prove that brachiopods occur in it; *Kingena lima* (Defr.) is the only species we have identified. There can be little doubt that a certain number of the brachiopods described by the late Mr. J. F. Walker, from bed D, came from this

Upper Gault deposit. Mr. Walker broke up and examined a large amount of material without discriminating between the blocks of Cenomanian limestone and those from the bed of earlier date. We consider that some specimens of ammonites in that part of the Walker Collection now preserved at Cambridge, kindly submitted to us by Mr. H. Woods for examination, belong without doubt to this earlier bed. They include *Leymeriella regularis* and a finely ribbed species of the same genus, derived from the *tardefurcata* bed, which, as we have shown, was undergoing denudation in the immediate neighbourhood at the time of the Upper Gault transgression. Another ammonite is a rolled fragment of a finely ribbed Perisphinctid, probably of Upper Kimmeridgian origin, of similar aspect to some of those found in the Lower Greensand of Potton; it may have been rederived from that or some similar deposit. We suspect that most of the fossils of Lower Cretaceous character recorded by Mr. Walker from bed D came, in reality, from this basal Upper Gault, in which they occurred as derivatives, and not from the Cenomanian limestone-lenticles. Further collecting on an extensive scale would be necessary in order to allocate to their right beds the species of different ages which were thought by Messrs. Lamplugh & Walker to illustrate a true commingling of life-forms.

The inverted lenticles of Cenomanian limestone lie side by side with the masses and patches of the basal bed of the Upper Gault. The lenticles have been forced down into the relatively soft material of the floor upon which the inverted mass rests. The constituent parts of the two beds, so interlocked and closely associated at the same level, illustrate an uncommon stratigraphical relationship of much interest. Some outer portions of the limestone-lenticles are occasionally seen to have become partly decomposed, and may then closely resemble the finer material of the older bed. The illusion is heightened by the pebbles in the limestone and by the ferruginous staining of both matrices; but the limestone-lenticles in all cases betray their true character by their included fossils.

A few words may be added here on the subject of the limonite-segregations, bands C and E, parts of which lie within the beds of Lower Greensand and Upper Gault just discussed. Referring to these ironstone-sheets, Mr. Lamplugh stated: "There is clear proof that they were in existence as rocky bands before the material now overlying them was deposited."[1] In support of this he called in evidence the fragments of ironstone incorporated in the breccia of bed D and the "polished and worn" surface of the "iron-pan floor" underlying the breccia. Reference was also made to some large blocks on the tip-heap of Harris's Pit, encrusted on their worn surfaces by adherent oysters and *Serpulae*. It was inferred that

[1] G. W. Lamplugh & J. F. Walker, "On a Fossiliferous Band at the top of the Lower Greensand near Leighton Buzzard (Bedfordshire)": Quart. Journ. Geol. Soc., vol. lix, 1903, p. 240.

these blocks belonged to the ironstone-bed E, which either formed part of the actual "floor" from which the fragments of ironstone in the overlying breccia had been derived, or represented the kind of local contemporaneous deposit in which they had their origin. We may remark that bed E, whenever seen by us, was of such a character as to be incapable of furnishing fragments for the spoil-heap similar to the large blocks described.

Mr. Lamplugh's later observations, recorded in his paper of 1908,[1] seem to give a clue to the origin of the encrusted blocks. In this later communication there is the description of a similarly encrusted sea-worn crag of "ironstone", a few feet across, within the glauconitic greensand then seen overlying the brachiopod-bed. This is clearly an indurated portion of the inconstant Upper Greensand bed. An examination of specimens of this rock obtained by Mr. Lamplugh shows that it differs essentially from the tabular limonitic bands, C and E. In some of the specimens there is shown a ferruginous and siliceous induration, probably of secondary origin, additional to the firm calcareous cementation seen in other parts of the rock; but even these more iron-stained portions do not in reality resemble the limonite-bands.

We thus recognize three distinct categories among the rock-bodies discussed by Mr. Lamplugh under the heading "The Iron-grit Bands".[2] Enumerating these in the chronological order of their formation we have, firstly, the flat fragments of ironstone (excluding the hæmatitic pebbles) incorporated as an original constituent in the Upper Gault bed, D_1; secondly, the indurated masses with worn and encrusted surfaces forming part of the bed of Upper Greensand; and thirdly, the thin undulating and branching sheets which have resulted from mineral segregation since Glacial time. The disposition of these connected sheets, occupying surfaces which mark two unconformable junctions and enclosing portions of beds belonging to three widely different geological dates (one of the beds being in inverted position), proves conclusively that the bands C and E are not an original part of the series. The smooth surfaces of the sheets are not incompatible with the later introduction of the limonite.

D. Relations of Gault and Cenomanian at the Main Outcrop.

The evidence so far obtained showed that a basal Cenomanian bed of special type formerly existed at the top of the outlier at Shenley Hill, and that the remnants of it seen there in inverted position owed their preservation to the fact that they had become sealed up under a protective mass of Upper Gault clay. It became desirable to ascertain if, anywhere towards the south-east and south, a similar bed at the base of the Chalk escarpment replaces the

[1] "Excursion to Leighton Buzzard": Proc. Geol. Assoc., vol. xx, pt. vi, 1908, p. 475.

[2] G. W. Lamplugh & J. F. Walker, op. cit., 1903, p. 240.

Cambridge Greensand of the country towards the north-east. No information on this point could be obtained from published writings, and an examination of the ground soon showed that the base of the Chalk was not to be seen in any natural exposure. The lower slopes of the escarpment are covered with a deposit of chalky downwash of variable thickness, and the line of outcrop of the basal bed is either concealed beneath this or is situated in the flatter ground under a cover of Boulder-clay.

The outcrop of the Cambridge Greensand, at the base of the Chalk Marl, is known to extend towards the south-west as far as the neighbourhood of Sharpenhoe, east of Harlington. Here the bed is thinning, and is developed as a bluish-grey sandy clay, about a foot in thickness, with green grains and many nodules. We began our investigations just south of this point, and probed the ground by boring or digging at several localities between here and Wendover. The result was to show that the evidence for a break in the sequence at the base of the Chalk, with signs of erosion, diminishes in a south-westerly direction.

At a spot one mile south-east of Harlington Church the basement-bed of the Chalk, as shown by fragments brought up by a hand-boring tool, was reached at a depth of 10 feet below the surface. It is overlain by 3 feet of cream and pale buff-coloured Chalk Marl, gritty and slightly glauconitic in the lowest foot. The basement-bed is here reduced to a layer which we estimate to be 2 to 3 inches thick. It consists of small well-rounded quartz-grains, black crumbs and polished grains (? phosphate), set in a fine creamy calcareous paste containing pebbles (up to $\frac{1}{2}$ in. in diameter) of rolled quartz-grit, fine quartzose sandstone, and subangular white chert, as well as black phosphatized fragments. This bed is underlain by pale Upper Gault Clay, assuming a darker bluish tint at a lower level.

At Kateshill, 3 miles north-west of Dunstable, a poor exposure in the road-cutting on Watling Street enabled us to ascertain that the basement-bed of the *varians* Chalk is an indurated grey calcareous sandstone with numerous small cream and grey-coloured phosphatic nodules, up to $\frac{1}{2}$ in. in diameter. This bed is underlain by the pale calcareous clay of the Upper Gault, with darker bluish clay at a lower level, as at Harlington.

At Totternhoe and Eaton Bray the outcrop of the base of the Chalk is masked by a thick deposit of chalky downwash. It was evidently due to an error that an outcrop of Upper Greensand at the village of Eaton Bray was represented on the Geological Survey map. The most careful inquiry failed to reveal any trace of it. A boring made in 1913–14 at Eaton Bray Nurseries (owned by Messrs. Wallace) on the Chalk outcrop as shown on the map, showed the presence of pale Gault Clay below the Drift. The Lower Greensand was reached at a depth of 243 feet below the surface. We are indebted to Mr. Wallace, jun., for allowing us to examine samples of the cores in his possession and for communicating to us the details

of this boring. Near Wendover, also, we failed to see the basement-bed of the Chalk. Finally, a visit was paid to the supposed outlier of Chalk at Billington, where the whole hill was found to consist of Gault Clay.

We conclude that to the south-east and south of Shenley Hill the basal bed of the Chalk was laid down in an area of deeper water than that in which the lenticles of gritty brachiopod-limestone of bed D at Harris's Pit were formed. This type of deposit must have had origin in shallower water, agitated by stronger currents. We must assume that these conditions prevailed in an area which included Shenley Hill, but did not extend to the present location of the outcrop; and that owing to the recession of the Chalk escarpment and the denudation of the outliers all traces of the bed in its normal position have been removed.

4. Interpretation of the Evidence.

The main points of our interpretation have already been stated in the foregoing description of the evidence, but it may be well to give a brief account of the succession of events which we believe to be deducible from the study of the sections at Shenley Hill. Our reading of the evidence may be conveniently considered under two headings: events during Cretaceous time and events during and since Glacial time.

A. Events during Cretaceous Time.

There is no reason to doubt that deposits of Lower Gault age at one time extended over the area now occupied by Shenley Hill.

Passage-beds from Lower Greensand to Gault, of *tardefurcata* age, are the highest strata at present exposed in this immediate neighbourhood, underlying the Upper Gault. Later beds became denuded away before the deposition of the Upper Gault. The Upper Gault rests discordantly upon these passage-beds and upon the underlying Lower Greensand, showing a thin basement-bed of mixed composition containing much coarse material. This débris includes relics of the destruction of the *tardefurcata* bed, in the shape of nodules and fossils. The active denudation accompanying the overlap resulted in the sweeping together of other remains from older strata then exposed, as may be inferred from some of the fossils obtained by the late Mr. Walker at Harris's Pit from rock-masses which comprised much material from this Upper Gault basement-bed.

During the progress of the transgression, deeper-water conditions soon supervened, as shown by the clays overlying the basement-bed. These were relatively unfossiliferous at first, and included a deposit of finely brecciated clay, apparently formed of materials derived from the destruction of some older clay. This passes upwards into marly clay containing the fauna characteristic of Bed IX at Folkestone. These relations indicate that the overlap probably coincides in date with the break marked by Bed VIII at Folkestone,

in which are nodules containing a *remanié* group of fossils; hence the transgressive strata are to be classified as *rostratus* Gault. The section at Harris's Pit proves that still higher beds of the *rostratus* zone were deposited. They are of a marly character and contain an ammonite-fauna (the "*catillus*" fauna) represented in the Upper Greensand of Wiltshire, below the *Pecten asper* beds, and in the Upper Greensand of the Isle of Wight just below the Chert beds. These highest Gault strata are now only exposed at Shenley Hill in the inverted mass at Harris's Pit. If present *in situ* anywhere in the higher part of the hill they are concealed beneath the Drift.

The bed of green sand observed by Mr. Lamplugh to be intercalated locally between the brachiopod-bed and the Gault Clay, in the inverted mass, has yielded fossils which, so far as they are known, indicate definitely a zonal position above the Gault; and we consider that this bed may be correlated provisionally with the *Pecten asper* Greensand. The abrupt transition from the clay to the sand suggests that the junction between them may represent a line of non-sequence; a considerable thickness of strata in the more expanded arenaceous series of Wiltshire appears to be unrepresented here. The inconstant occurrence of this Upper Greensand bed, with rapid thickening, and the fact that where it is absent the basal Cenomanian bed with brachiopods is separated from the *rostratus* Gault only by a thin layer of ironstone of later origin, point to a denudation of the uppermost part of the Selbornian series prior to the deposition of the basal Cenomanian bed, with a corresponding degree of non-sequence. This period of denudation produced still more far-reaching effects in the region of the Cambridge Greensand, in parts of which, at least, the removal of much of the Upper Gault was also involved.

The next bed to be considered is the brachiopod-bed, which consists of isolated limestone-lenticles, forming the lowest part of the inverted mass. This affords ample evidence of its age and of the conditions under which it was deposited. Its indigenous fauna is that of the sub-zone of *Catopygus columbarius* at the base of the Cenomanian stage as understood in this country; and it has not been proved that the bed contains fossils derived from older strata. As already stated, the Lower Cretaceous species recorded by Messrs. Lamplugh & Walker from the brachiopod-bed were in all probability found in the basal bed of the Upper Gault, where they would occur as derivatives. It is improbable that the strata which formed the true source of these older fossils were exposed to denudation at the time when the basal Cenomanian deposit was laid down.

We have remarked upon the close similarity of the limestone-lenticles to the gritty limestone found in part of Northern France at the base of the *varians* zone. Captain W. B. R. King, who sent over specimens of this rock during the recent War, informs us that it occurs at Matringhem in isolated lenticles occupying hollows in

a floor of Devonian sandstone. This compares closely with the mode of occurrence of the similar lenticles at Shenley Hill and adds strength to our inference that we have here a basement-bed of the *varians* Chalk, laid down during the period of early Cenomanian movement and transgression. No later deposit of Cretaceous age is preserved at Shenley Hill.

The above brief description of events during Cretaceous time explains much confusion in the account of the strata offered by Messrs. Lamplugh & Walker. The brachiopod-bed (D) of those authors was ascribed by them to the Lower Greensand. In reality it consists of rock-masses belonging to the basal bed of the Chalk and the basal bed of the Upper Gault. The idea of a "peculiar" faunal assemblage, founded on a collection of specimens obtained from the rocks of both zones, was bound to be erroneous, particularly in view of the fact that some Lower Cretaceous species were found which were not indigenous to either of these horizons. Mr. Walker's recognition of so many links with the Tourtia-faunas of the Continent, whichever local "Tourtia" it might be, now gains a new significance. Transgressive basement-beds formed under conditions of active erosion are likely to contain species derived from any fossiliferous stratum of earlier age exposed to denudation at the time.

B. Events during and since Glacial Time.

It is evident that before the advance of the ice-sheet the Upper Gault in the neighbourhood of Shenley Hill was capped in places by the remnants of the Upper Greensand, with the lenticles of basal Cenomanian age extending over both. It is impossible to say whether any of the Chalk Marl here had still survived the ordinary processes of subaerial denudation. So far as the overturned mass of strata is concerned, no Chalk Marl was present.

The inversion of the sheet of strata now seen in an abnormal order of succession at Harris's Pit must be regarded as an effect of the glaciation of the district. The elevation of the ground probably opposed an obstacle to the advancing ice-sheet,[1] with the result that a huge mass of *rostratus* Gault and its thin capping of later strata became detached, carried forwards towards the south or south-east and completely overturned upon a floor formed, on the lower ground, by the basal part of the Upper Gault. It seems improbable that such a large mass could have been transported far from its original site.

It is remarkable that there are so few signs of disturbance at the present base of the inverted beds; and although there is sufficient evidence of squeezing, disruption, and confusion in the present state of the topmost bed of the substrata, this is only such as might result from simple crushing, without any continued forward movement of the transported mass after it reached its new resting-place.

[1] Compare remarks by H. B. Woodward, "The Chalky Boulder-clay and the Glacial Phenomena of the Western Midland Counties of England": Geol. Mag., 1897, pp. 495–6.

We may suggest that the coherence of the clays and sands would be increased by freezing, and that the transported sheet of strata may have been moved very slowly into its new position while held firmly in the ice-stream, and deposited upon snow or snow-covered ice. The subsequent melting would proceed so gradually as to let down the mass on to its new substratum with a minimum of disturbance. It may have been at that time that the limestone-lenticles of the inverted upper surface of the boulder became forced down by pressure into the yielding material of the floor.

While no known agency except the movement of an ice-sheet is adequate to have produced the result now seen, a consideration of the exact *modus operandi* may be left to those who have had more experience in the study of glacial phenomena. Sir Archibald Geikie has commented on the difficulty of conceiving how extensive thin sheets of soft strata can have been ploughed out of their place and pushed forward.[1]

This striking example of glacial transportation falls into line with the similar instances along the tract of country to the north-east. There is the well-known mass of Cretaceous strata at Roslyn Hill Pit, Ely, discussed in papers by the late Osmond Fisher and by Professor T. G. Bonney;[2] while at Biggleswade, near Bedford, a mass of Ampthill Clay nearly 70 feet thick has been found incorporated in the Boulder-clay.[3] Numerous other examples of the transportation of large masses or "cakes" of Jurassic and Cretaceous rocks in the Midland area have been recorded by various writers.[4] We may also refer to the boulder of Cretaceous strata 240 yards in length at Leavad, in Caithness.[5]

It is impossible to say how far glacial erosion, subsequently to the removal of the inverted strata to their present position, may have reduced the thickness of the mass. It may be remembered, however, that the fauna found at the present top of the reversed beds of Gault shows that the whole of the Upper Gault in situ at Shenley Hill can have been little more than 40 feet in thickness. Hence it appears certain that in relation to its area, the whole mass must have been thin from the time of its detachment. Again, we prefer to leave a discussion of this purely glacial aspect of the problem to those who are better qualified to offer an opinion.

[1] In a discussion on Mr. Home's paper, cited below, p. 381.

[2] O. Fisher, "On Roslyn or Roswell Hill Clay-pit near Ely": Geol. Mag., 1868, p. 407. T. G. Bonney, "Notes on the Roslyn Hill Clay-pit": Geol. Mag., 1872, p. 403. Also *Cambridgeshire Geology*, 1875, p. 69.

[3] H. Home, "On a transported mass of Ampthill Clay in the Boulder-clay at Biggleswade, Bedfordshire": Quart. Journ. Geol. Soc., vol. lix, 1903, p. 375.

[4] For references to some striking cases see H. B. Woodward, op. cit., 1897, p. 495.

[5] R. G. Carruthers, "On the occurrence of a Cretaceous Boulder of unusual size at Leavad, in Caithness": Summary of Progress for 1910 (Mem. Geol. Surv.), 1911, p. 80. D. Tait, "On a large glacially transported mass of Lower Cretaceous Rock at Leavad, in the County of Caithness": Trans. Edin. Geol. Soc., vol. x, pt. i, 1911.

We may refer once more, in conclusion, to one of the changes which have taken place within the beds exposed in Harris's Pit and in the base of the local Gault of neighbouring sections since the recession of the ice. This is the formation of conspicuous tabular sheets of ironstone, resulting from the growth of mineral segregations. The present appearance of these undulating bands seems to speak for their formation for the most part during some period of post-Glacial time remote from the present day. It is probable that the process of ferruginous segregation took place most actively during some distant time under wetter climatic conditions, when there would be freer percolation of waters beneath the surface. The overlying clay must be regarded as the source from which the iron was derived.

It is possible that the chief part of the masses of iron-grit in the upper portion of the current-bedded Lower Greensand were formed by similar induration during the same period. We have noted that in one place in Garside's Pit one of these large masses is merged with a thin tabular band of iron-grit at the base of the overlying Upper Gault; while in a neighbouring part of the section the tabular band retains its individuality and is distinctly separable from the sand below it. The segregation would occur mainly along the lines of more easy permeability. This is in agreement with the observed development of the tabular ironstone-bands principally along surfaces of discontinuity in the series; thus, at the unconformable junction between Lower Greensand and Upper Gault; at the base of the overturned mass of strata; and above the basal Cenomanian deposit, which we have shown to be in contact with the overlying beds along a surface of erosion, with some degree of non-sequence. The ironstone is also present along minor planes of dislocation. The more uniformly porous nature of the false-bedded Lower Greensand would permit a freer diffusion of the mineral substances concerned in producing the induration; hence the larger size and more irregular boundaries of the masses of iron-grit situated in those sands. The vitreous character shown in parts of these masses must be ascribed to secondary siliceous induration.

The above interpretation of the remarkable section at Shenley Hill differs in every essential particular from that put forward by Messrs. Lamplugh & Walker; but it is in accord, we believe, with all the observed facts and does not violate any established principle of zonal palæontology.

5. Summary of Conclusions.

We may summarize our chief conclusions as follows:—

(1) The brachiopod-bed of Shenley Hill, as described by Messrs. Lamplugh & Walker, who referred it to the Lower Greensand, is shown by stratigraphical and palæontological evidence to be of a composite character. Its constituent parts belong respectively

to the basement-bed of the Upper Gault and to the basement-bed of the Cenomanian stage, as understood by English geologists (sub-zone of *Catopygus columbarius*).

(2) The Cenomanian bed is present in the form of isolated lenticles of limestone. Although no comparable stratum can be found at the present outcrop, which has receded from the area where conditions produced this particular type of deposit, the bed has a close lithological counterpart in Northern France (Matringhem), where there is an almost identical bed at the base of the *varians* zone.

(3) At Harris's Pit the Cenomanian bed, an inconstant layer of Upper Greensand formerly seen above it, and an overlying mass of Gault Clay of *rostratus* age are in an inverted order of succession. There is a junction of erosion and non-sequence between the Gault and the Cenomanian bed.

(4) The normal unbroken passage from Lower Greensand to Lower Gault (*interruptus* zone) is shown south of Leighton Buzzard in more complete development than in other sections hitherto described in this country. The series here includes a sandy passage-bed of *tardefurcata* age (with the *Leymeriella*-fauna) overlain by *interruptus* clay, as in parts of the Continent.

(5) The Lower Gault has not been seen at Shenley Hill, where there is an overlap of Upper Gault upon the Lower Greensand. The basal bed of the Upper Gault is here of mixed and variable constitution, with much coarse material, containing relics of the denudation of the *tardefurcata* bed. It passes up first into clay, then into more marly clay containing the early *rostratus* fauna of Bed IX of Folkestone, the highest Gault as yet seen at Shenley Hill *in situ*. The hill forms an outlier of the upper *rostratus* beds.

(6) At Harris's Pit the overturned mass of strata rests upon the basal bed of the Upper Gault, with which the Cenomanian limestone-lenticles have become intermingled. In neighbouring sections a thin remnant of the overlying Upper Gault Clay is present in normal sequence.

(7) The fossils recorded by Messrs. Lamplugh & Walker as occurring in the brachiopod-bed, of alleged Lower Greensand age, came in part from the Cenomanian limestone and in part from the basement-bed of the Upper Gault. The earlier of these strata would be likely to yield specimens derived from the *tardefurcata* bed and from lower zones, thus accounting for the supposed intermingled character of the fauna of the brachiopod-bed.

(8) It may be roughly estimated that the overturned mass was originally some 250 yards in length, in north and south extension, and upwards of 150 yards in breadth; its westerly boundary has not yet been reached in the sand-workings.

(9) The inverted mass of strata became removed from its original site during the glaciation of the district, as in the case of the transported masses at Biggleswade, Ely, and elsewhere. It was probably derived from the higher ground to the north or north-west of its

present location, where the outlier at that time was capped by the basal Cenomanian bed, or by remnants of it.

(10) Thin ironstone-bands which form a conspicuous feature in the section at Harris's Pit are developed principally along surfaces of stratigraphical discontinuity. Their disposition within the strata of both the normal and the inverted parts of the sequence shows that they were formed by mineral segregation subsequently to the glaciation.

The present study emphasizes a lesson. Since the whole fabric of stratigraphy is built upon the determination of age-relationships among superimposed deposits, it follows that an essential of sound stratigraphical work lies in the full utilization of all available palæontological criteria. If these be neglected, the data for correct conclusions are incomplete, and the investigator may thus permit himself to be deceived by the apparent simplicity of a stratified series. The stratigrapher is too often dismayed by the complexities of palæontological classification and nomenclature; but the determination of the age of successive strata does not necessarily demand an excursion into this forbidding domain. It can usually be compassed without the naming of species. Nevertheless, some knowledge of the faunal characterization of zones, as well as familiarity with the principles underlying the right application of that knowledge, must always form part of the indispensable equipment for stratigraphical work. The trouble involved in the use of these means for age-determination, however irksome it may seem, can no more be evaded than that which must necessarily be taken in the study of lithological characters and relations, from which are deduced the conditions under which sedimentation has taken place.

In the case of a composite fossil fauna consisting of derived and indigenous elements, the criterion of age is to be sought among the zonally latest life-forms and not among the earlier ones. The determination of age is then based upon previous experience of uniformities, both as regards biological facies and zonal restriction. Its accuracy is thus directly proportionate to the known invariability of the faunal and chronological inter-relation.

The elementary truths embodied in these remarks have been brought home to us by many workers since the days of William Smith; in more recent years by the illuminating researches of Charles Lapworth, S. S. Buckman, A. W. Rowe, and other investigators; but there is perhaps no illustration of them more convincing than that afforded by the study of Shenley Hill.

Finally, we desire to express our indebtedness to those who have kindly given help in the present investigation; to Mr. Gregory Harris and Mr. George Garside, who permitted us to visit their sand-pits; to Mr. Henry Woods for a list of fossils in the J. F.

SYNOPTIC VIEW OF THE TWO INTERPRETATIONS OF THE SECTION IN HARRIS'S PIT.

Lamplugh and Walker.			*Kitchin and Pringle.*
			. . Lower *rostratus*-Gault, with fauna of Bed IX, Folkestone.
B = Lower Gault, *in situ*.	B		B = Upper Gault mass, inverted.
Inconstant greensand-bed at base = ? *Mammillatus* bed.			. . Higher *rostratus*-Gault with "*catillus*"-fauna of Upper Greensand of Wilts and Isle of Wight. Inconstant greensand at base = ? *Pecten asper* zone.
Contemporaneous iron-grit floor	C		. . Post-Glacial limonite-band, along lines of unconformity and non-sequence.
Fossiliferous top of Lower Greensand	D		. . Composite bed: basal Upper Gault *in situ*, basal Cenomanian inverted.
Contemporaneous iron-grit floor	E		. . Post-Glacial limonite-band, along line of unconformity.
	F		Lower Greensand of pre-*tardefurcata* age.
	G		
Beds C to H = Lower Greensand.	H		. . False-bedded Lower Greensand.

Note.—For convenience, the column of strata is not represented in true scale.

Walker collection at Cambridge, with notes on certain of these, and for the loan of specimens; to Mr. T. H. Withers for his report on the Upper Greensand cirripedes; to Dr. B. Pope Bartlett for reporting on rock-specimens and fossils of Upper Greensand and Cenomanian age submitted for his opinion; and to our colleagues Mr. C. B. Wedd, for many helpful criticisms, and Mr. W. Manson, for the skill and care with which he has prepared the drawings for our illustrations.

Carboniferous Fossils from Siam.

By F. R. Cowper Reed, M.A., Sc.D., F.G.S.

(PLATE II.)[1]

Introduction.

IN 1899 the Cambridge Exploring Expedition to the Malay Provinces of Lower Siam collected a few fossils and many rock-specimens at a place named Kuan Lin Soh, in the Patalung district. A small broken image of Buddha from the temple of Bah Nah containing some similar fossils was considered to have been quarried from the same beds, and it was believed that these specimens represented strata of Cretaceous age.[2]

In the following year a brief report on the same material was made by the late Professor T. McK. Hughes,[3] and he was led to regard the fauna as indicating the highest beds of the Carboniferous or the Permo-Carboniferous, basing his conclusions on the following rough determination of the fossils: "*Proetus* sp., encrinite stems and arms, several species of lamellibranchs and brachiopods, including at least one species of *Chonetes*, *Pleurotomaria* sp., and a cephalopod with horse-shoe lobes." Special attention was paid to the lithological characters of the rocks in which the fossils occurred, and two types were recognized by Professor Hughes: (1) a grit of varying coarseness without determinable fossils, and (2) a very fine rock composed almost entirely of silica, with practically no lime, but some alumina.

It is the latter rock which has yielded the organic remains here described, the coarser rock not having any recognizable fossils in it.

The fossiliferous rock is of a curious and uncommon character, having an argillaceous or even chalky appearance, though thin sections and chemical analyses prove that it is almost entirely composed of minute grains of silica. When fresh it is tough and hard, with rarely a shaly and usually a subconchoidal fracture. It is whitish in colour, but occasionally is stained yellow or pink. It becomes soft and pulverulent when weathered and more or less decomposed, with a chalky feel and aspect.

[1] This Plate will appear in the March issue.

[2] Report Brit. Assoc., Bradford, 1900, pp. 393–8.

[3] Report Brit. Assoc., Glasgow, 1901, p. 414.

The fossils, which are scarce and mostly fragmentary, are in a poor state of preservation, consisting either of crushed internal casts or external impressions, with the shell sometimes retained as a thin film.

It was felt that a more detailed examination of the material than was given in 1900–1 might yield fuller and more definite results, and Professor Hughes accordingly entrusted me in 1915 with the task, as the specimens had been deposited in the Sedgwick Museum. A large number of fragments have been carefully broken open or split, and by this means it has been possible to augment to a considerable extent the list which Professor Hughes gave in 1901, and to fix with more certainty the stratigraphical position of the beds. The fauna proves to be of peculiar interest, and in the almost total ignorance of the geology of this district of Siam the following notes may be of value to future investigators in these parts.

Pronorites aff. *cyclolobus* (Phillips). (Pl. II, Fig. 1.)

The late Mr. G. C. Crick kindly examined for me the single specimen of a cephalopod in the collection which shows a suture-line distinctly, and he considered that the shell was referable to the genus *Pronorites* and allied to the Carboniferous species *Pr. cyclolobus* (Phillips).[1] Our specimen shows about the last quarter of the outer whorl and a portion of the body-chamber; four suture-lines are preserved. The more strongly marked horseshoe-shaped saddles and the blunter or even rounded second lateral and accessory lobes, and the fact that the first and second lateral saddles nearly touch respectively those of the preceding suture-line and overlap the bases of the preceding adjoining lobes, are features which distinguish it from the typical *Pr. cyclolobus*. The whole shell when perfect must have measured about 20–25 mm. in diameter.

Prolecanites (?) sp.

Some poor impressions of the exterior and some flattened imperfect internal casts of a goniatite may perhaps be referable to a species of the genus *Prolecanites* rather than to *Pronorites*, but the reference is uncertain. The shell was apparently discoid and laterally compressed with all the whorls (6–7) exposed in the wide, shallow, open umbilicus. The overlapping of the whorls appears to have been slight, but the outer whorl increases more rapidly in size than the inner ones, and there are some traces of a more complicated suture-line than in *Pronorites*. Perhaps *P. compressus* (Sow.)[2] and *P. mixolobus* (Phill.)[3] may be compared with it; the latter is

[1] Phillips, *Geol. Yorkshire*, 1836, pt. ii, p. 237, pl. xx, figs. 40–2. Foord and Crick, *Cat. Foss. Ceph. Brit. Mus.*, pt. iii, 1897, p. 264, text-fig. 125, p. 261.

[2] Sowerby, *Min. Conch.*, vol. i, 1813, p. 84, pl. xxxviii. Foord & Crick, *Cat. Foss. Ceph. Brit. Mus.*, pt. iii, 1897, p. 252, fig. 121.

[3] Phillips, *Geol. Yorks*, pt. ii, 1836, p. 236, pl. xx, fig. 43; Foord & Crick, op. cit., p. 254.

recorded by Crick[1] from the Coddon Hill Beds of Devonshire, which are closely similar lithologically as well as faunistically with the Siamese deposit, and the same species is a characteristic one of the "Posidonienschiefer" of the Harz and of Geigen, near Hof. There is apparently another species of *Prolecanites* or more probably *Nomismoceras* represented in the collection, but it is too poorly preserved for determination.

Glyphioceras (?) sp.

One slab of rock contains many much-crushed casts and impressions of a subglobose cephalopod with a broad rounded back and large convex outer whorl, slowly increasing in size, but almost completely overlapping the inner whorls, which are exposed in a small, deep, umbilicus with rectangular (?) edges. A few widely distant concentric constrictions cross the outer whorl. This shell may belong to the genus *Glyphioceras* (cf. *Gl. mutabile* Phill.),[2] or to *Gastrioceras* (cf. *G* (?) *Kayseri* Loczy,[3] of the Carboniferous of China), but there is not sufficient of it known to determine its relations. Mansuy[4] has doubtfully recorded the genus *Glyphioceras* from the Carboniferous of Eastern Yunnan, but it is a well-represented genus in the "Posidonienschiefer" of the Harz.

Pleurotomaria (*Mourlonia*) aff. *conica* Phillips. (Pl. II, Fig. 2.)

There is one portion of a shell of a *Pleurotomaria* half imbedded in matrix and somewhat crushed, but it can be seen to have been a low trochiform shell of 4–6 whorls, rapidly increasing in size and with an apical angle of 70–80 degrees. Each whorl is rather sharply angulated at the band, which in the basal whorl is peripheral, but on the upper whorls is situated a little distance above the suture-line. The apical surface of the whorls is slightly excavated just above the band, but becomes gently convex near the suture-line. Below the band the umbilical surface of the basal whorl seems to have been strongly convex, but it is rather crushed and has a concentric fracture simulating a revolving ridge. The margins of the band are sharp and prominent. The surface of the whorls is crossed by strong, regular, transverse, curved striæ, which are of almost equal size and nearly equidistant, and they meet the band on the apical surface at about 30 degrees or less, but apparently are nearly at right angles to it below. Dimensions: height (estimated) about 17 mm., basal diameter about 19 mm. With regard to its

[1] Crick, Quart. Journ. Geol. Soc., vol. lv, 1895, p. 652.

[2] Phillips, *Geol. Yorks*, pt. ii, 1836, p. 236, pl. xx, fig. 26. Crick, *Cat. Foss. Ceph. Brit. Mus.*, pt. iii, 1897, p. 181 (and references). Holzapfel, *Palæont. Abhandl.*, vol. v, pt. i, 1889, p. 29, t. ii, figs. 2–6.

[3] Loczy, *Wiss. Ergebn. Reise Szechenyi in Ostasien*, Bd. iii, 1898, p. 44, t. i, figs. 7, 7*a*. Schellwien in Futterer's *Durch Asien*, Bd. iii, Lief. i, 1903, p. 139, t. i, figs. 1, 2.

[4] Mansuy, Mem. Surv. Geol. Indochine, vol. i, fasc. ii, 1912, p. 87, pl. xvi, fig. 5.

affinities, this shell seems to resemble *Pl. conica* Phillips,[1] of the Carboniferous Limestone, which Mrs. Longstaff[2] thinks may belong to the subgenus *Trechmannia* rather than to *Mourlonia* sens. str. The figure of a shell named *Pl. vittata* Phill. by Holzapfel[3] also bears a considerable resemblance to our specimen, and we may also compare the species *Pl.* (*Mourl.*) *Cayeuxi* Mansuy,[4] described from the Dinantian of Eastern Yunnan.

Euomphalus cf. *subcircularis* Mansuy. (Pl. II, Fig. 3.)

Several specimens of small planorbiform shells, with an average diameter of about 8 mm., may perhaps be compared with Mansuy's *E. subcircularis*[5] from the Carboniferous of Eastern Yunnan, though there are many European species which may be allied. The shell is coiled in a flat spiral of 5–6 rounded whorls, nearly subcircular in section and increasing very slowly in size, with a submarginal carination on the upper surface dying out towards the mouth. The spire is rather sunken, being slightly depressed below the level of the outer whorl, and the open umbilicus is also concave. Rather strong concentric striæ cross the whorls.

Helminthochiton cf. *priscus* (Münster). (Pl. II, Fig. 4.)

There is one symmetrical sub-semicircular and subconical plate of a species of *Helminthochiton* measuring 6 mm. in diameter, which agrees in general characters with the anterior plate of *H. priscus* (Münst.) as described and figured by De Koninck.[6] The slightly raised small median apex projects a little behind the angulated posterior end, and from the apex there radiate on each side a pair of submarginal fine straight grooves separating low rounded ridges. A rather large crescentic shelly process or shelf projects at a lower level behind the posterior end of the plate, and is crossed by a narrow triangular fissure which is doubtfully an original feature.

Parallelodon aff. *corrugatus* De Koninck. (Pl. II, Fig. 5.)

There is one right valve of a shell which is referable to the genus *Parallelodon*, but like the other fossils it is badly preserved. In shape it is transversely rhomboidal; the inferior margin is gently sinuated; the posterior end is rounded-subtruncate; the beak is broad, low, obtuse, and situated at about one-third (or less) the length of the shell; and the surface is ornamented with very fine radial lines and concentric growth-lines, the latter becoming stronger near the margin. In length the valve is about 15·5 mm., and in height about 9·5 mm. It appears to be allied to *P. corrugatus* De Koninck, as described

[1] Phillips, *Geol. Yorks*, vol. ii, 1836, pl. xv, fig. 22.
[2] Longstaff, Quart. Journ. Geol. Soc., vol. lxviii, 1912, p. 303.
[3] Holzapfel, *Palæont. Abhandl.*, vol. v, pt. i, 1889, p. 50, t. vi, fig. 14.
[4] Mansuy, op. cit., vol. i, fasc. ii, pt. ii, 1912, p. 89, pl. xvi, fig. 7.
[5] Mansuy, op. cit., vol. i, fasc. ii, pt. ii, 1912, p. 105, pl. ix, figs. 3*a*–3*d*.
[6] De Koninck, *Faune Calc. Carb. Belg.*, vol. iv, 1883, p. 199, pl. l, figs. 37–48; pl. li, fig. 36; pl. liii, figs. 21–9.

by Wheelton Hind,[1] but the ornamentation is finer. We may also compare, as regards general shape, the Culm shell from Hagen, figured by Nebe[2] as *Macrodus* cf. *normalis* De Koninck.

Edmondia sp. (Pl. II, Fig. 6.)

One internal cast and external impression of a small oval shell measuring 10·5 mm. in length and 8·5 mm. in height has the anterior and posterior ends subequally rounded; the inferior margin is strongly arched, and the beak is obtuse, broad, and less than one-third the length of the shell from the anterior end. The surface is covered with strong subangular, rather unequal rugæ. It seems comparable to *Edmondia MacCoyi* Wh. Hind,[3] but has not such blunt extremities. Mansuy[4] has described a species of *Edmondia* from the Carboniferous of French Indo-China, but it does not seem to be identical with our form.

Allorisma (?) sp.

One imperfect right valve of an elongated shell which has a somewhat swollen and incurved beak and strong concentric rounded undulations of subequal size, directed slightly obliquely to the length of the shell, seems probably comparable with *A. sulcata* (Fleming).[5] The anterior end seems rather abruptly truncate, and the posterior end rather sharply rounded; there is a strong rounded umbonal ridge running down to the latter end, with a very weak, wide depression in front of it, crossing the shell to the inferior margin, which is faintly sinuated. The length of the shell is about 24 mm., and the height at the anterior end about 10 mm. Species of *Allorisma* have been recorded from the Upper Carboniferous of Sumatra.[6]

Protoschizodus (? ?) sp.

The occurrence of a species of this genus is suggested by some very imperfect casts too poor for precise identification.

Posidonomya Becheri Bronn, var. nov. *siamensis*. (Pl. II, Fig. 7.)

Shell obliquely suboval to subrhomboidal, posteriorly expanded and flattened, with a long, gently curved or nearly straight hinge-line, rather less than the length of the shell; posterior margin gently and continuously arched, meeting hinge-line at very obtuse angle; inferior margin more or less sharply rounded; anterior margin nearly straight, with weak, wide, shallow sinuation at base of long narrow triangular ear; hinge-line meeting anterior margin at about 75

[1] Wheelton Hind, *Mon. Brit. Carb. Lamell.*, vol. i, p. 140, pl. x, figs. 16–19.
[2] Nebe, *Neues Jahrb. f. Miner. Geol.*, Beil. Bd. xxxi, 1911, p. 458, t. xiv, fig. 7.
[3] Wheelton Hind, *Brit. Carb. Lamellibr.*, vol. i, p. 329, pl. xxxvi, figs. 23–30.
[4] Mansuy, op. cit., vol. ii, fasc. v, 1913, p. 25, pl. iv, fig. 6.
[5] Wheelton Hind, op. cit., p. 422, pl. xlviii, figs. 3–11.
[6] Fliegel, *Palæontographica*, Bd. xlviii, 1901, pp. 108–9.

degrees. Body of shell very gently convex, sharply marked off from anterior ear; umbo acute, directed forwards, situated at about one-third length of hinge-line or subterminal. Surface of shell covered with strong regular, concentric undulations, triangular in section, of equal or subequal strength and size, becoming less regular on anterior ear and smaller and weaker on posterior portion of shell, with fine, straight, radiating lines crossing them in middle part of valves. Some fine concentric lines are also occasionally present on the undulations. Dimensions: (I) height (oblique), 30 mm.; length (parallel to hinge-line), 23 mm. (II) height (oblique), 80 mm.; length (parallel to hinge-line), 55 mm.

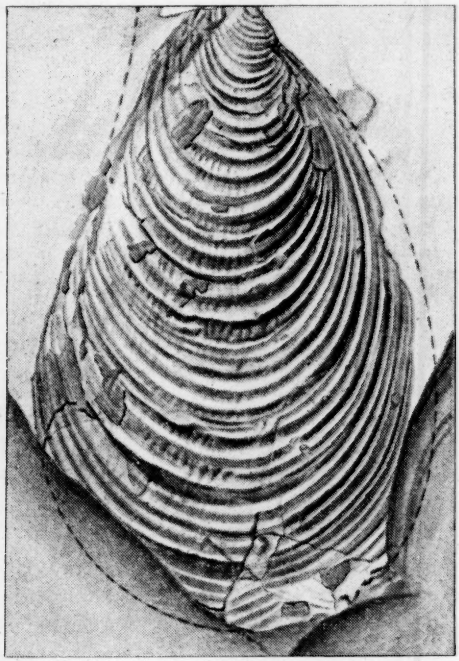

FIG. 1.—*Posidonomya Becheri* Bronn, var. nov. *siamensis*.

Remarks.—This is the species which occurs on the small broken image of a Buddha from the temple of Bah Nah. There are several more or less perfect examples of various sizes on it, and one shows both valves in juxtaposition and well preserved. The largest specimen is imperfect. The ornamentation is like that of *Posidonomya Becheri* Bronn;[1] but with regard to the characters of this genus there is considerable diversity of opinion. Zittel says it has no ears, whereas

[1] Wheelton Hind, op. cit., vol. ii, p. 27, pl. vi, figs. 11–15.

Wheelton Hind says it has a rounded anterior ear and a compressed expanded posterior ear. The anterior ear is well seen in our complete specimen, which has both valves preserved, and in this example the ear seems relatively wider and larger than in the other specimens. In the largest shell the umbo seems subterminal, and the whole shell more elongated and less rhomboidal. Distortion often affects the shape of specimens of *Posidonomya*, and some of the difficulties and differences of opinion with regard to its characters result from this cause. There is a shell figured by De Koninck as *P. plicata*[1] which bears much resemblance to our specimens, and the Culm shells from North Devon, which Phillips[2] figured and described as *P. Becheri* and *P. lateralis* Sow. may also be compared. Diener[3] has referred some indistinct casts in the Anthracolithic beds of Spiti to this genus, but otherwise it does not seem to have been recorded from the Carboniferous of Asia.

The discovery of specimens of this shell at Kuan Lin Soh in a rock precisely similar to that of the image from Bah Nah, and their occurrence in the same rock as the rest of the fauna, fixes the age of the specimens in the image.

Posidonomya (?) cf. *radiata* Wh. Hind.

There is an imperfect impression of the greater part of the left valve of an obliquely ovate shell about 11 mm. high, with a gently convex surface marked by fine concentric lines and straight, radiating, broad ribs which are of rather unequal strength and width, being sharp, narrow, and strong near the posterior margin, but low and weak in the middle. So far as its characters can be determined, there is a resemblance of this shell to *Posidonomya radiata* Wh. Hind,[4] but the generic reference of this species seems open to doubt.

Pseudamusium cf. *pratenue* Von Koenen. (Pl. II, Fig. 8.)

There is one right valve of a species of a pectinoid shell represented in the collection by an internal cast and external impression, which resembles *Pecten pratenuis* Von Koenen[5] from the Culm of Germany. It measures 13 mm. in length and 10 mm. in height. In shape it is obliquely oval and very inequilateral; the beak is small, acutely pointed, directed forwards, and subanterior in position. The body is nearly flat and well marked off from the narrow elongated depressed posterior ear, which reaches about half-way down the posterior margin. The anterior edge of the shell is strongly arched forwards below the very small projecting anterior ear, which seems

[1] De Koninck, op. cit., p. 182, pl. xxxix, fig. 8.
[2] Phillips, *Palæoz. Foss. Cornw. Dev.*, 1841, pp. 44–5, pl. xx, figs. 73–4.
[3] Diener, Perm. Foss. Centr. Himal.: *Palæont. Ind.*, ser. xv, *Himal. Foss.*, vol. i, pt. v, 1903, p. 138.
[4] Wheelton Hind, op. cit., p. 31, pl. vi, figs. 6–9.
[5] Von Koenen, *Neues Jahrb. f. Min. Geol.*, 1879, p. 329, t. vi, figs. 3, 4.

to have a deep byssal notch below it. The posterior margin of the posterior ear meets the hinge-line at a very obtuse angle. The surface of the body has a few strong, but low, concentric undulations and finer concentric lines. Wheelton Hind [1] considers Von Koenen's species to be identical with Salter's *Aviculopecten fibrillosus*, which he puts in the genus *Pseudamusium*. *Ps. auriculatum* (McCoy) [2] may also be compared.

Aviculopecten cf. *densistria* (Sandberger). (Pl. II, Fig. 9.)

The right valve of a small pectiniform shell, of which the impression and external cast are preserved, is practically indistinguishable from the Culm species described and figured by Von Koenen [3] as *Pecten densistria* Sandberger.[4] Our specimen has a height of about 6 mm. and a width of about 5 mm.

Actinopteria sp.

The impression of the left valve of a small shell, about 9·5 mm. in length, appears to belong to the genus *Actinopteria* or *Pteronites*. In general shape, position of beak, size of pre-umbonal portion, hinge-line, and convexity of body, it resembles the Scotch species, *Pteronites fluctuosus* Etheridge,[5] which Hind [6] refers to the genus *Actinopteria*, but the ornamentation is rather different, consisting in our specimen of numerous very fine, equidistant, regular radiating lines, more closely placed on the flattened posterior half of the shell behind the body, on which concentric growth-lines are also present.

(*To be continued.*)

Escarpments and Transverse Rivers.

By Henry Bury, M.A., F.G.S.

At the end of a valuable paper on the superficial deposits to the north and north-west of London, Mr. Barrow [7] puts forward certain views as to the origin of escarpments and transverse rivers in the Chiltern Hills and the Weald which can hardly be allowed to pass unchallenged by those interested in the progress of geomorphology, for *unless there is more evidence in their favour than has yet been produced* these views are not progressive, but distinctly reactionary. To sum up the position in his own words (op. cit., p. 47): "Long after the cessation of all the bending movements

[1] Wheelton Hind, op. cit., vol. ii, 1903, p. 106, pl. xvi, figs. 16–22.
[2] Ibid., p. 108, pl. xvi, figs. 23–7.
[3] Von Koenen, op. cit., p. 327, t. vi, fig. 2.
[4] Sandberger, *Rhein. Schichtsyst. Nassau*, p. 296, t. xxx, fig. 12.
[5] Etheridge, Geol. Mag., Vol. X, 1873, p. 345, Pl. XII, Fig. 1.
[6] Wheelton Hind, op. cit., p. 25, pl. v, figs. 8–12.
[7] Proc. Geol. Assoc., vol. xxx, 1919, pp. 1–48.

which produced the present structure of the Thames Valley, there was a fall of sea-level or a rise of the sea-bottom that brought the beds within reach of marine erosion. As a result the sea steadily ate its way far inland along the outcrops of the two masses of soft material, the Eocene beds and the Gault, leaving four projecting ridges, the two inner ones formed of Chalk, now the Chalk escarpments, and the two outer ones formed of Lower Greensand. In course of time the sea breached the Chalk ridges in a number of places (the majority of which are now windgaps), and through the gaps thus formed a great quantity of quartz-pebbles, etc., from the Lower Greensand were carried."

Those who are familiar—and what geologist is not?—with the old controversies of last century on the Denudation of the Weald, will recognize here a return, in all essential points, to the "marine" theory of the formation of escarpments and windgaps, which many of us imagined to have been completely and finally overthrown by the arguments of Greenwood, Ramsay, and other founders of the "subaerial" school. The hypotheses advanced by these writers were afterwards enlarged as our knowledge of river development grew, and in their improved form have been applied by Professor Gregory[1] and Professor W. M. Davis[2] to the very region with which Mr. Barrow deals, and it is therefore singular that he should discard these views without giving his reasons, and return to the old marine hypothesis without any comment on the difficulties thereby incurred.

It would take up too much space and serve no useful purpose to recapitulate all the arguments by which that hypothesis was opposed, but the two principal are—(1) that the postulated series of narrow, parallel arms of the sea following the strike of the strata has no counterpart in modern geography; (2) that it affords no satisfactory explanation of the origin of transverse rivers and their constant relation to the dip. Bearing these objections in mind, let us see how far the subaerial theory is invalidated, and a return to marine action compelled, by the new facts contained in Mr. Barrow's paper. After tracing the small quartz pebbles of the various drifts back to beds, now largely destroyed, of early (? Pliocene) age—the "Pebble Gravel" of Mr. Whitaker—he shows that this material must have come from the Lower Greensand, entering the Eocene region through at least one of the windgaps of the Chiltern Hills; and he also expresses the opinion that the Thames Valley was invaded by the sea at the same period. All this is quite compatible with the subaerial hypothesis, but that does not satisfy Mr. Barrow, who says,[3] "Without going into minute details, it will be sufficient for the present to say that this type of transit across the Gault could hardly have taken place unless that had an almost even surface

[1] *Nat. Sci.*, vol. v, 1894, pp. 97–108; Geol. Mag., 1914, pp. 145–8.
[2] Geogr. Journ., vol. v, 1895, p. 145.
[3] Op. cit., p. 40.

and formed the bottom of a shallow sea, which passed through the gaps, breaking the Chalk escarpment up into a series of islands."

No evidence is offered that the sea ever reached the foot of the escarpment at all; and even if such evidence were produced, we should still ask for proof that it was the sea which formed the gaps, and not the gaps (as drowned river valleys) which admitted the sea. But it is as an explanation of the transference of quartz pebbles from the Lower Greensand to the Chalk that the hypothesis seems to have been framed, and here the interpolation of a narrow arm of the sea between the two lines of strata would seem to be rather a hindrance than a help to such migration, and it is submitted that unless very strong reasons against it can be given, the hypothesis of transference by transverse rivers is both simpler and more efficient. No less unsatisfactory is the account given of the origin of the transverse rivers themselves. We are told that[1] "When the elevation above sea-level" (of the sea-bottom in the Gault) "took place . . . local streams would tend to form, flowing through all the gaps". But this is by no means obvious. It has been held that the absence of longitudinal rivers running directly to the sea from the Weald is evidence against the marine origin of the escarpments and river system of that region; and similarly here we might expect that, if the sea entered from the east along the lines of weak strata, it would retreat in the same direction, thereby giving rise at once to a longitudinal drainage.

It must not be supposed that a subaerial origin for the windgaps is inconsistent with any influence of the sea in determining the drainage system of the South-East of England. On the contrary, it leaves untouched the question whether that system originated on an uplifted marine plain; and it is by no means opposed to the possibility that the sea, which seems at one time to have filled the London Basin, may, during periods of temporary depression, have made its way along the foot of the escarpments, as it seems to have done through the drowned valleys of the South Downs in Pleistocene times.

Nor must I be thought to wish in any way to depreciate the value of Mr. Barrow's work. It is only to some of his theoretical views that I take exception, because they appear to me retrogressive and unsupported by the facts so far before us. If there are other facts necessitating a radical change of view, it is to be hoped that they will soon be published.

[1] Op. cit., p. 40.

Some Microchemical Methods.

By Alfred Brammall, B.Sc. (Lond.), F.G.S., Imperial College of Science and Technology, South Kensington

THE well-known and highly sensitive tests afforded by ferricyanide, ferrocyanide, and thiocyanate solutions for the detection of iron may be adapted, at the cost of a little trouble, to the microchemical investigation of certain rocks in thin section, as can also the equally well-known fusion test for manganese. The following methods have proved useful in special circumstances of the nature indicated in each case.

1. The necessity arose to determine the distribution of hydrated ferric matter in sediments affected by low-grade metamorphism, and to detect any marked tendency towards the accumulation of this substance in and about foci of recrystallization. Method applied to rock slices: The cover-glass having been removed, the slice is first cleansed of balsam, then polished, again cleansed, and warmed to evaporate any spirit retained by capillarity. Meanwhile, reaction papers are prepared: a piece of white drawing-paper, of area about twice that of the rock slice, is soaked in strong HCl and pressed between sheets of similar paper until it is no longer "wet"; an ammonium thiocyanate paper is prepared in a similar way. The acid paper is carefully laid upon the slice and covered with a strip of cardboard on which is laid a hot iron (2–3 lb. weight), care being taken not to shear the slice. After two or three minutes the weight, cardboard, and paper are carefully lifted from the slice, which is allowed to dry; the thiocyanate paper is applied (the same precautions being observed) and pressed, in the cold, to ensure good contact with the slice for a few minutes; it is then removed and the slice is again thoroughly dried before being examined in transmitted light. The distribution of ferric iron is revealed by a transparent blood-red stain of $Fe(CNS)_3$.

Potassium ferrocyanide may be substituted for the thiocyanate, but the blue coloration produced is due to an opaque pigment, which must be examined in reflected light. The thiocyanate stain has the advantage of transparency.

(*a*) The method has proved of especial value in the examination of "spotted" rocks; a typical case is described: In a Knotenschiefer from Andlauthal, Vosges, the spots, conspicuous enough in hand specimens, are differentiated from the matrix in thin section only by the following features: (i) abundant inclusions of opacite (carbon, largely); the inclusions in some spots traversed by pigment-rich bedding planes appear to have been derived, in part, from these planes, which are relatively free from this opaque matter for a short distance on each side of the spot; (ii) an irregular, brownish, transparent stain forming a peripheral zone; (iii) polarization colours sensibly lower than those of the matrix; some spots may be almost isotropic. On microchemical treatment the

spots yield a pronounced stain, while the matrix takes only a feeble stain on the whole; the peripheral zone is somewhat less responsive to treatment than the rest of the spot, but ultimately is stained throughout.

(*b*) The dark inclusions in chiastolite (andalusite) react very feebly, but the narrow opaque zone of matrix immediately surrounding the crystals usually reacts very strongly. The stains on the thiocyanate paper itself are worth examination.

(*c*) The alteration of chiastolite (andalusite), yielding structures closely resembling those observed in olivine altering to serpentine, often involves permeation of the mineral by iron-rich water impregnating the matrix; the channels of alteration and their dust-filled dilations then react strongly for iron.

(*d*) Lamination in shales is frequently emphasized by narrow bands rich in opaque (carbonaceous) matter; these layers are also usually rich in some easily soluble compound of "ferric" iron—a feature which may be, in part, at least, original, and possibly due to the incompatibility of iron with colloidal organic matter in solution, the two substances being precipitated together.

(*e*) Magnetite being much more easily soluble in HCl than ilmenite (or titanoferrite), it reacts much more readily by this test than does the latter. The reaction papers in this case should be prepared from blotting-paper, and should be slightly "wet", so that the thiocyanate stain may spread somewhat by capillarity; the stain on the thiocyanate paper itself should not be disregarded.

The rare occurrence of grains of native iron in certain rocks is more readily detected by applying a wash of slightly acidulated $CuSO_4$ solution, which coats the iron with a film of metallic copper, recognizable in reflected light.

(*f*) The method is also useful for demonstrating the distribution of chalybite in oolitic ironstones and less ferruginous oolites. Although chalybite is dissolved readily by HCl in the cold, the weight used to press down the acid reaction paper upon the rock slice should be hot so that the hydrated ferrous chloride first formed may be the more rapidly oxidized to the basic ferric chloride; the acid is in sufficient excess to convert some of this basic compound to the normal ferric salt. As the products of reaction with HCl are hydrates and very hygroscopic, the application of the thiocyanate paper tends to produce smearing; this is largely prevented by using reaction papers which are not "wet", by drying the preparation in a hot atmosphere or a desiccator after each reaction, and by examining the preparation without delay.

It is well to supplement the thiocyanate preparation by two others, using potassium ferricyanide and potassium ferrocyanide on separate slices; the blue pigment produced is examined by reflected light. The deliquescent $CaCl_2$ may be removed by first thoroughly drying the preparation (so as to "cake" the pigment) and then carefully washing it—the pigment remaining fixed.

On comparison of these preparations it is seen that (i) chalybite—often partly oxidized to limonite—may be located in a narrow peripheral zone of an oolith or in roughly concentric zones forming the greater part of the oolith, or (ii) chalybite may compose the entire structure. A nuclear mosaic of calcium carbonate granules may be the residue of an original aragonite oolith,[1] which is undergoing metasomatic replacement by chalybite, the latter being usually present in the matrix.

2. In the investigation of minute structures—stream lines and channels—in certain ottrelite-bearing rocks it was desired to determine whether the mineral matter infilling these channels contained an appreciable quantity of manganese. The test applied is described below. Such structures are very minute, and the results of the test require close scrutiny, otherwise significant spots may be overlooked and the reaction may appear too vague to be of much value.

A slice is ground down until it is about the thickness of a florin, and one side is polished. The slice is detached from the glass slip, cleansed of balsam, and dried (at about 150 degrees to desiccate the slice, and, if possible, promote fissures along the channels); it is then allowed to soak for several minutes in a hot saturated solution of $K_2CO_3 + KNO_3$, and dried. A thin wash of the hot solution is applied to the polished surface, the slice is again dried and laid on a tile, polished surface uppermost; this surface is subjected to the F.P. tip of the blowpipe flame for a few minutes, and when cold it is slightly polished to level (not to remove wholly) the thin veneer of "melt". The slice is then mounted (prepared surface downwards) in balsam, ground down as thin as possible, and examined by transmitted light. Before the blowpipe a slice which is too thin tends to buckle, and it may be necessary to break it up, after treatment, into two or more flakes to be mounted separately.

3. Bedding planes in chalk and limestone are often indistinguishable; nevertheless, extremely thin laminæ may be relatively rich in foreign matter (volcanic or meteoritic dust, for example), and these may be brought to light by the following method—approximating to a process of weathering: A specimen of the rock is ground evenly and polished in one or more selected directions, washed, and immersed in a bath of carbonated water. By differential solution, controlled by lack of homogeneity, bedding-planes, minute structures, etc., may be revealed. (Foraminifera rarely escape solution unless the water is very feebly carbonated; the process is then extremely slow.) The bath should be rocked occasionally, but very gently, otherwise delicate and significant structures may be obliterated.

[1] Rastall, *Nature*, July 3, 1919, p. 359.

A Curious Fossil Charophyte Fruit.

By James Groves.

THROUGH the kindness of Mr. Henry Woods, I have had the opportunity of examining three blocks of limestone belonging to the Sedgwick Museum at Cambridge, which were collected by the late E. B. Tawney, from the "Chara Bed", Etage Oeningien, Upper Miocene, at Locle, Jura (Canton Neuchatel, Switzerland). The blocks contain a number of the remains of fruits of a species of Charophyte, which present a feature I had not hitherto observed, and to which I think attention may advantageously be drawn. Before describing this peculiarity, however, it will be desirable to say something as to the conditions of preservation in which such bodies are usually found.

In living species of *Chara*, *Lamprothamnium*, *Lychnothamnus*, *Nitellopsis*, and *Tolypella*, when the fruits are more or less mature, the five spiral-cells which form the sac of the oogonium often secrete a deposit of lime extremely fine and close-grained, almost porcelain-like in texture. The lime is gradually deposited on the inner wall of each spiral-cell, that is, on the side adjacent to the oospore, often only partially, but in its fullest development almost entirely, replacing the original protoplasmic contents of the cell. The lime-contents of the five spiral-cells combine to form a firm hard shell, known as the lime-shell, which envelopes the oospore, and is no doubt protective in character. When the fruit becomes dry and the soft part collapses, if the lime deposit is thin, each of the spiral-cells appears as a rounded furrow. The concavity of the cells decreases in proportion as the lime deposit thickens, becoming flat or even convex when the cell is completely filled. Neither the five cells forming the coronula nor the single stalk-cell secrete lime.

Apparently in almost all cases it is to the presence of such a lime-shell that we owe the preservation of charophyte fruits as fossils, and it is noticeable that the one living genus, *Nitella*, which does not produce a lime-shell, is not known in the fossil state. The remains of charophyte fruits, ordinarily found as fossils, consist of the sac formed by the five spiral-cells only, without either the coronula or the foot-stalk, and therefore correspond with the lime-shell. Occasionally the oospores are found in the sacs. We find the spiral-cells in the fossils in all stages of thickness, ranging from the very thin concave bands in some types, which I refer to *Tolypella*, to the thick convex coils found in some specimens of the *Chara medicaginula* type.

On the interior surface of some of the fossil oogonium sacs one comes across a layer of soft fine white lime of varying thickness, but usually much thinner than the hard darker outer shell. In the specimens of which I am writing it is in this inner layer of white

lime that the unusual feature occurs in the shape of a tubular hollow, which follows the course of each of the spiral-cells, as shown in Fig. 1, *B, C*. I had previously assumed that the layer of white lime was simply a deposit, extraneous in origin, which had taken place between the oogonium sac and the possibly shrunken oospore. The presence of these uniform tubular hollows in Mr. Tawney's specimens, and the division of the white line into regular bands, as shown in the illustration, however, seems to point to an organic origin.

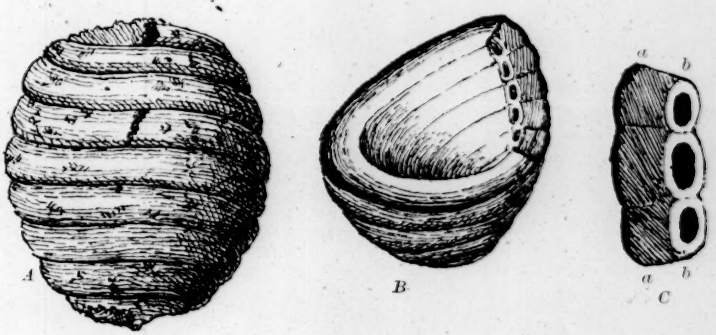

FIG. 1.—Fruit of fossil Charophyte from Locle, Switzerland. *A*. Nearly entire oogonium, × *circa* 31. *B*. Broken specimen, showing section of part of the wall of the oogonium and an internal layer of soft white lime with tubular channels, × *circa* 31. *C*. Transverse section (diagrammatic of three of the petrified spiral-cells forming the wall of the oogonium), *a a* with the corresponding bands of the white lime layer, *b b* having compressed tubular channels shown as black ovals, × *circa* 65.

I am at present unable to suggest any explanation of this problematic feature, and the main object of this note is to draw attention to its occurrence, in the hope that those having the opportunity of investigating freshwater deposits will keep a look-out for charophyte fruits, which may throw some light on the development in question.

I have not seen authentic specimens of *Chara Merianii* Braun, which is reported from the Miocene of Switzerland and Baden, but conclude from Heer's figures in *Flora Tertiaria Helvetiæ* that the specimens under consideration belong to that species.

REVIEWS.

EQUIDÆ OF THE OLIGOCENE, MIOCENE, AND PLIOCENE OF NORTH AMERICA: ICONOGRAPHIC TYPE REVISION. By H. F. OSBORN. Memoirs of the American Museum of Natural History, New Series, Vol. II, Pt. I, 1918. pp. 217, with 54 plates and 173 text-figures.

THE work issued under the foregoing title is a systematic revision of the hundred and forty-six described species of Oligocene–Pliocene horses of North America, with reproductions of the original figures, new figures of many types, and a series of plates of comparative drawings. It is intended to clear the ground for President Osborn's long-looked for monograph of the Equidæ and is intentionally restricted to statements of fact with only that irreducible minimum of theoretical conclusions essential in such a work.

In the opinion of the reviewer it is the most impressive palæontological work which has ever been published. The short, absolutely clear, and workable generic and specific diagnoses, the simple and straightforward arrangement, the extreme lucidity of the comparative drawings, the abundance, perfection, and accurate dating of the material, inevitably leave the reader with an overwhelming feeling that here the mode of mammalian evolution is shown in detail for the first time, and shown in the best possible way by arranging the facts in order and leaving them to speak for themselves.

When the final monograph is published, with President Osborn's critical interpretations of the different phyla within each genus, and of the evolution of each part considered in detail by itself and in correlation with the rest of the structure, we shall have the most adequate material which can at present be made available for a critical discussion of biological theories of evolution.

Palæontologists and zoologists have been long acquainted with the series of generic stages leading up to *Equus*, as they have been established by the American palæontologists; but none except those who have been so fortunate as to see the American Museum collections can have had any conception of the completeness of the story, and even those who have handled that vast series could not previously appreciate the infinitely close gradation between the species of a single genus which occur at different horizons.

As the importance of palæontological material depends entirely on the fact that the relative ages of the species forming a series are known, President Osborn begins his monograph with a most useful account of the stratigraphy and correlation of the many localities of North America which yield horse remains. The whole series of North American Tertiary land deposits is now divided into zones on mammal evidence, and some progress has been made

in correlating these with marine deposits. The extremely careful collecting carried out by the American Museum parties has established these zones on a firm stratigraphical basis, and has even allowed of a record of the position of individual specimens within their zone. Thus much of President Osborn's material fulfils in the highest degree the first demand of a palæontologist. Of the Oligocene genus *Mesohippus* eighteen species are described, the upper teeth of nine of which, figured in order of age, show a steady advance in structure by stages which are individually scarcely recognizable, until the latest form passes into the genus *Miohippus*, the line separating the two genera being of purely arbitrary position. The upper teeth of seven species of *Miohippus*, figured in order of age, show an exactly similar steady change, until the latest form *M. gemmarosæ* differs scarcely at all from the most primitive *Parahippus*, *P. pristinus*. From this form there is a complete structural passage to such advanced forms as *P. brevidens*, which differs very little from the earlier *Merychippi*, such as *M. isonesus primus*. Of this species there is a series of five mutants, in Waagen's sense, not that of de Vries, occurring in order in about 25 feet of sediments, the latest of which, *M. i. quintus*, differs much more in tooth-structure from *M. i. primus* than the latter does from the advanced *Parahippi*. More advanced species of the very complex genus *Merychippus* lead insensibly into *Protohippus*, *Pliohippus*, and *Hipparion*, and many stages of the later evolution of these genera can be traced in the material.

There are thus known about three dozen stages between the most primitive *Mesohippus* and the most advanced *Pliohippus*, and the gaps separating these stages are all of extremely small magnitude, so small that when more material is published they will inevitably disappear entirely, because the structures change steadily with time, and the size of the structural gap between two specimens depends on the time interval which separates them. The present work being concerned with type-specimens does not include those forms of intermediate structure which are not of specific or good mutational rank.

These steady changes in definite directions are shown not only in the teeth but in skull structure and proportions, and especially clearly in the interlocking relations of the carpals and tarsals.

The fundamental conclusions which, although they are never mentioned in the text, are forced on the reader of this monograph, especially by the comparative plates, are: that the evolution of the horses has proceeded steadily with time by the steady accumulation of changes of infinitely small magnitude, without or with only the extremely rare and unimportant occurrence of saltations: that the changes are steadily in the same direction until a character is fully formed and functional: that series of changes of identical character go on in distinct but parallel phyla, which may in some cases be traced through from genus to genus.

None but those who have handled similar material can have any idea of the vast amount of work of the highest class concealed behind the unpretentiousness of this superb monograph. President Osborn expresses his acknowledgments to his colleagues, Gidley, Granger, and Matthew, to the published work of many other American palæontologists, to Professor J. C. Merriam, to his assistant, Miss Ripley, and to the artists, Messrs. Oka and Yoshihara, and Mrs. Stirling.

This memoir represents the result of "team work" by eminent students fused into one by that palæontologist whose studies have gradually established those philosophical principles on which modern methods of palæontological investigation very largely depend. It provides a triumphant vindication, had one been necessary, of the soundness of the policy adopted by Professor Osborn of sending out on collecting expeditions year after year those palæontologists who are going to work up the material acquired. Only in this way is it possible to attain that certainty of horizon which is essential for satisfactory work. Had dependence been placed on the purchase of collections and on the sporadic gatherings of geologists, this work would have forever remained impossible, because the zonal classification, probably the most detailed and satisfactory one known, could not have been worked out and the horizon of any specimen would always have been open to doubt.

D. M. S. Watson.

The Grimaldi Caverns.

Les Grottes de Grimaldi (Baoussé-Roussé). Tome I, Fasc. IV: Géologie et Paléontologie (*fin.*). By Marcellin Boule. pp. 237–362, pls. xxx–xli. Monaco, 1919.

Professor Boule is to be congratulated on the completion of his important work on the remains of vertebrate animals found with man in the caverns of Grimaldi on the south coast of France. It is not merely a technical treatise on fossil bones and teeth, but also a general discussion of the Pleistocene mammalian fauna, of very wide interest. The final instalment deals with the Carnivora, Insectivora, Cheiroptera, and Rodentia, besides more fragmentary remains of birds, reptiles, and amphibians. It then ends with a summary of the results.

Professor Boule points out that the succession of a warm fauna (*Elephas antiquus*, *Rhinoceros mercki*, *Hippopotamus*, etc.), a cold fauna (glutton, ermine, marmot, reindeer, etc.), and then the modern fauna, is as clear in the low latitude of the French Riviera as in the rest of Central and Western Europe. He correlates the first (or Chellean) period with the third interglacial period of Penck, and the following (or Mousterian) period with the Würmian glacial episode of Penck. He adds maps showing the geographical

distribution of some of the most important species of mammals, and in several cases he illustrates the relationships of the Pleistocene forms by elaborate genealogical tables. His observations on the lynx are especially interesting, for he shows that the extinct race of Grimaldi is precisely intermediate between the existing northern race and that still found in Spain.

THE SCHRAMMEN COLLECTION OF CRETACEOUS SILICISPONGIÆ IN THE AMERICAN MUSEUM OF NATURAL HISTORY. By Dr. MARJORIE O'CONNELL. Bull. American Mus. Nat. Hist., vol. xli, 1919. pp. 261, with 14 plates.

THE palæontologist soon learns to divide newly published matter into two categories, that which gives more trouble than the information offered is worth, and that which, by saving the reader trouble, aids him in acquiring the new knowledge it has to impart. A glance at the work under review leaves no doubt in which category it should be placed. While the amount of new information it contains may not be great, it is not likely that anyone wishing to gain a general knowledge of Cretaceous Sponges will consult this work in vain, or, having read it, will put it down without understanding how far our present knowledge of the subject goes, or without knowing what works to consult for further information.

But he will have learnt more than this. The trouble he is saved is the clearing away of unnecessary obstacles to knowledge, and not the trouble of taking pains. A glance at pp. 34–46 shows the ordeal to be undergone before you or I can become a good disciple of "Palæospongiology" (a blessed word, but a mealy mouthful). The terminology of spicules is a lacerating tangle of Amphitorns, Cricamphityles, Diancistras, and such like, from which one emerges only to come upon Ophirhabds ("long, smooth monaxons of irregular or snake-like curvature, generally tapering towards both ends"), with but a Tox ("bow-shaped spicule") and a Labid ("spicule shaped like sugar tongs") for self-defence—and there are more than a hundred of these thorny terms. But having mastered the spicular terminology and learned how to apply it—here is the test of its utility—the student of fossil Sponges may feel well equipped for further study, and may reasonably hope that the difficulties of the future will be considerably less than those already overcome. As a student, the complex terminology of types (pp. 99–101), following closely that of Schuchert and Buckman, but incidentally concerns him this is mainly the curator's care; but he will welcome the detailed account of the European Cretaceous formations and the earth history of that epoch in Europe (pp. 47–97), finding here the means of correlating local terminology with stratigraphical terms of wider meaning. This, with a useful historical résumé of work on Sponges as a group, a geographical analysis of the literature of Cretaceous Sponges, a detailed systematic

description of the Schrammen Collection in the American Museum of Natural History, and a bibliography of over two hundred works, finishes what is not merely an account of the Schrammen Collection in America, but much more, a very complete introduction to the study of Cretaceous Sponges as a whole.

It is hardly a just cause for complaint that the authoress's nationality appears in her writing. No Englishman who loves his land would refer, in speaking of the Dover district, to the "nearby cliffs along the Kentish coast" (p. 59). "Arkosic" (p. 81) is a strange word; and "Cretacic", however defensible, is both strange and ugly, and does not appear to be used in any sense different from the familiar "Cretaceous", unless it is that Cretacic is American Cretaceous; for "Cretaceous" is used, e.g. on pp. 52, 61, and 84, as well as in the title of the paper. "Disconformably" for "Unconformably" is unfamiliar. The following misprints have been noticed: "Morven" (p. 62) apparently should be "Morvan"; on p. 72 "northern" is evidently a misprint for "southern"; on p. 91 "*cornea*" should be "*carnea*"; and on p. 154 "*Acorchordonia*" should be "*Acrochordonia*". On pp. 150, 188, etc., "*Callopegma acaulis*" is written for "*C. acaule*".

Since the book under review is ostensibly a work on Sponges, this is hardly the place to criticize in detail the stratigraphy expounded on pp. 47–97. But this otherwise admirable resumé is somewhat marred by the fundamental misunderstanding of the "zone", apparent generally, but explicit in the remark (p. 52) "as in all such faunal work, the cephalopods, being pelagic, are considered the most reliable in the establishing of zones of limited vertical, but wide horizontal extent, for which reason the standard zonal subdivisions of the Cretaceous are based upon the Ammonites".[1] Now, if I read its founder, Oppel, rightly, the "zone" is that sediment (if any) which was deposited during a given time in the earth's history. For convenience, it is named after a fossil occurring in it (not necessarily throughout it) in one locality (almost necessarily not all over the world). How, then, can a zone be referred to relatively as "of wide horizontal extent", when a zone is necessarily worldwide? And how can "zonal subdivisions" be "based upon Ammonites" when only their names are based upon fossils? (It may also be remarked that to imply that Ammonites were pelagic is an assumption, even if it is generally true that other Cephalopods are and were.)

The authoress also appears to think that the zone of *Pecten asper* in the South-West of England is usually included in the Albian rather than in the Cenomanian, for on p. 57 she writes: "I shall include therein [in the Cenomanian] the Warminster fauna of the *Pecten asper* zone, since it would otherwise be difficult to compare with the figures for entire faunas on the Continent, where the

[1] The division, by Grossœuvre, of the Chalk into zones named after Ammonites is given in tabular form, with correlations, on p. 50.

rocks containing *Pecten asper* are always recognized as marking the base of the Cenomanian." It served to emphasize the fact that the *P. asper*-zone is Cenomanian, that Jukes-Browne invented the term "Selbornian" for the Albian (including the zone of *Mortoniceras rostratum*) *plus* the *P. asper*-zone of the Cenomanian, for convenience in writing of the Upper Greensand of the South-West of England. Incidentally Jukes-Browne, not recognizing the zonal name as a mere label, quite unnecessarily altered the name of the zone from *P. asper* to *Cardiaster fossarius*, on the ground that *P. asper* was not commonly found in Devon and Dorset.

It might be supposed from a perusal of this work that in order to study the Cretaceous Sponges of North-West Germany, it is necessary to visit the collection in the American Museum of Natural History. But the British Museum possesses a very large collection of these sponges, named by Dr. Schrammen, and purchased from him some eighteen years ago. Specimens from this collection are figured on plate iii of the British Museum Guide to the Fossil Invertebrate Animals, a circumstance not noticed by Dr. O'Connell. The collection, though lacking many of the forms described in the work under review, yet contains many species not represented in the American collection. Considering, too, how well the British forms are represented, including as they do Toulmin Smith's types as well as those of the numerous species described by the late Dr. Hinde, the student of Cretaceous Sponges has all the material in the British Museum for ground-work, as well as for extended research, and armed with Dr. Marjorie O'Connell's handbook should be better equipped for this study than is the student of many another invertebrate group for his special task.

It may be gathered from what has been written how valuable a book Dr. O'Connell has produced—one which in its thorough treatment puts the new-comer at his ease by showing him exactly where he stands in relation to his subject. Such a work should be a stimulus to writers on other invertebrate groups and challenges imitation.

W. D. Lang.

A Report on Magnetic Disturbances in Northamptonshire and Leicestershire and their Relations to the Geological Structure. By Arthur Hubert Cox, M.Sc., Ph.D., F.G.S. Phil. Trans. Roy. Soc. (A), vol. 219, pp. 73–135.

THIS paper is published as an appendix to the Magnetic Re-survey of the British Isles for the epoch January 1, 1915, by Mr. G. W. Walker. The earlier surveys of Rücker and Thorpe had revealed the existence of sundry areas of special disturbance, not evidently related to anything in the known geological constitution, and these disturbances are confirmed by the new survey. To elucidate their probable cause two areas were selected for more comprehensive

examination, one lying between Melton Mowbray and Nottingham, and the other in the ironstone district of Irthlingborough. Additional magnetic observations were carried out by Mr. Walker, and Dr. Cox was commissioned to make a geological and petrological study of the two areas and to discuss the results, a duty which he has accomplished with much skill and judgment.

The problem is quite different from that presented by the much greater magnetic disturbances in the Western Isles of Scotland, which are manifestly due to permanent magnetization of rocks at the surface. Here, on the other hand, we have to do with induced magnetism, and Mr. Walker's observations indicate that the seat of the disturbance in Northamptonshire is at a depth of not less than 3,000 feet. The inference is that rocks of noteworthy magnetic susceptibility are in place at some considerable depth beneath this area, and that there is some irregularity in their distribution. Discussion of underground geology necessarily involves an element of the hypothetical; but the author is able to muster a sufficient number of data bearing on the question. He has made a list of all the rocks which are likely to occur beneath the district, and examined their petrographical characters, while determinations of magnetic susceptibility have been furnished by Professor Ernest Wilson. Dr. Cox points out that this property in different rocks is closely correlated with their content of magnetite. A granite containing only a little magnetite has a much higher susceptibility than a basic rock rich in iron in the form of silicates and in ilmenite.

The author ascribes the disturbances to the presence of dolerites as intrusions in the subjacent Coal-measures. Such dolerites are well-known in other parts of the Midlands, and they possess a higher magnetic susceptibility than any other rocks in that region. It may be mentioned that the investigation was undertaken primarily in the hope of detecting concealed iron-ores in this way, and the possibility should certainly be kept in view in relation to like magnetic disturbances elsewhere. Such cases as that of the Rosedale ore in Cleveland show that an isolated body of bedded magnetite-rock may occur in the midst of a formation which elsewhere carries only iron-oxides and carbonate. We have, however, no grounds for conjecturing such an occurrence beneath Northamptonshire, and intrusive dolerites seem to afford at least a good provisional explanation of the facts. The inferred irregularity of their distribution is attributed to faulting, and the author shows that the observed magnetic disturbances in this area correspond closely with faults which are mapped in the Mesozoic strata, and almost certainly extend into the underlying Palæozoic rocks. The disturbances near Irthlingborough can be referred to the Jurassic iron-ores of the district, which pass from ferrous carbonate in the interior into hydrated ferric oxide at the weathered outcrop, with a consequent diminution in magnetic susceptibility.

A. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

December 17, 1919.—Mr. G. W. Lamplugh, F.R.S., President, in the chair.

In the absence of the author, the following paper was read by Mr. R. D. Oldham, F.R.S., V.P.G.S.: "A Rift-Valley in Western Persia." By Professor S. James Shand, D.Sc., F.G.S.

Asmari Mountain, near the oilfields of Maidan-i-Naftun, in the Bakhtiari country of Western Persia, is an inlier of Oligocene limestone among the beds of the Fars System (Miocene), the latter consisting, in the lower part, of bedded gypsum with intercalated shales and a few thin limestones. The mountain is a whale-back, 16 miles long and 3 miles wide at the middle, formed by a simple symmetrical anticline plunging at both ends. The north-western end plunges rather steeply, and shows no abnormal structures; but at the south-eastern end the fold has collapsed along its length for a distance of 3 miles, letting the gypsum beds down into a trough in the limestone.

This trough is bounded by two main faults hading north-eastwards and south-eastwards respectively, with an average hade of 20°, and marked by steep escarpments. The northern scarp, which lies practically along the axis of the anticline, is at one point 500 feet high; but the southern one, being low down on the flank of the anticline, is much less conspicuous. Besides these main faults there are at least three other big faults parallel to them, which produce minor scarps within the valley: the valley-floor thus descends in terraces towards the south-west, besides having a general south-eastward inclination of some 10°. Uphill, towards the crest of the mountain, the downthrow of the limiting faults diminishes gradually to zero, and the valley dies out on the broad top of the anticline. Downhill, towards the plunging nose of the anticline, the trough is closed abruptly by a cross-fault nearly at right angles to the anticlinal axis. The length of the whole trough is 2½ miles, and its width half a mile.

The northern boundary-fault at its maximum has a downthrow of about 500 feet, the parallel faults range from 150 to 200 feet, and the cross-fault throws about 100 feet.

The gypsiferous beds which once completely filled the trough have been partly removed by erosion, clearly revealing the fault-walls in the lower part of the valley. These fault-scarps in their lower portions are remarkably fresh, and show the smoothed and fluted surfaces produced by the friction of the sliding faces.

The drainage of the faulted region is curious in several respects. The only perennial stream that traverses the valley cuts sheer across it from side to side. Rising in the gypsum beds on the north-eastern flank of the anticline, the stream turns south-

westwards, and cuts right through the limestone in a deep cañon; the latter breaches the northern fault-scarp where the downthrow is greatest, and from here the bed of the stream lies in the gypsum of the valley bottom, except for a short stretch between two faults, where the limestone floor is again exposed to view. The stream finally breaks through the southern limestone wall, and so makes its escape from the valley.

These conditions imply that the river assumed approximately its present direction when there was a cover of gypsiferous beds over the whole area, and that, although younger than the initiation of the faulting, it is older than the sculpturing of the inside of the fault-trough. The eastern end of the trough is again tapped by another and smaller stream with a precisely similar development.

It might be surmised from the excellent preservation of the fluted surfaces on the fault-scarps that the last movement took place at a very recent date, but the behaviour of the river in crossing the scarps does not favour this supposition. The succession of events appears to have been as follows:—

(1) Formation of the trough with gypsum-infilling by partial collapse of the anticline.

(2) Levelling of the gypsum surface and development of a stream across the position of the buried trough.

(3) The stream, cutting down through gypsum, discovers the faults, etches them out, develops subsequents along them, and thus gradually eats out the gypsum filling the rift, until the present topography results.

January 7, 1920.—Mr. G. W. Lamplugh, F.R.S., President, in the chair.

1. "On *Syringothyris* Winchell and certain Carboniferous Brachiopoda referred to *Spiriferina* D'Orbigny." By Frederick John North, B.Sc., F.G.S.

This paper is the outcome of a suggestion made in 1913 by Professor T. F. Sibly, who pointed out the desirability of an attempt to remove the uncertainty which had hitherto existed in the naming of the British species of *Syringothyris*, and of the Carboniferous Spiriferids possessing a lamellose surface ornament, which it was customary to refer to *Spiriferina* because there was no other genus for their reception, although it had long been recognized that few, if any of them, really belonged to that genus.

After indicating the exact sense in which certain frequently occurring terms are used, and reviewing the history of previous research, the author discusses the history in Avonian times of the genus *Syringothyris*, and suggests a classification of its species.

Variations due to time, to environmental conditions, and to distribution in space, are recognized, and distinctive names are given to the mutations characteristic of certain horizons.

The syrinx (it is suggested) was a special arrangement called into existence to control the direction of and to support the

adductor muscles as the area of the shell increased in height. It, and the transverse plate to which it was attached, originated as a modification of an apical callosity such as existed in many Spiriferoid shells. It was initiated in Middle Devonian times, and reached its acme early in the Carboniferous Period.

All known species of *Syringothyris* have the fold in the brachial valve, and the sinus in the pedicle-valve, smooth. Species such as *S. distans*, in which the fold and sinus are plicated, do not possess a syrinx, and are incorrectly referred to *Syringothyris*.

The form described by McCoy as *Spirifera laminosa* is referred to a new genus, since it has neither the punctate shell-structure of *Spiriferina* nor the internal characters of *Syringothyris*. The genus is represented in the Lower Avonian by mutations of the species *laminosa* McCoy, and in the Upper Avonian by the species *subconica* Martin.

Syringothyris and *Spiriferina* are in no way related, either morphologically or phylogenetically.

The small Carboniferous shells that have hitherto been referred to *Spiriferina* include two types characterized by external differences. Of these two types, one, in which there are numerous ribs and a relatively large rounded fold and sinus, is relegated to a new genus; while the members of the other type, which include shells with a few large angular ribs, are for the present retained in *Spiriferina*, although the type-species of that genus was derived from the Lias The subdivision here suggested for the Carboniferous forms will, it is believed, prove to be applicable to the later species also.

2. "Jurassic Chronology: I—Lias. Supplement 1, West England Strata." By S. S. Buckman, F.G.S. (Read in the absence of the author by Dr. W. D. Lang, M.A., F.G.S.)

In this communication the following points are discussed:—

(1) The Ammonite and some Brachiopod faunas of the Lias of Gloucestershire and Worcestershire.

(2) A method of faunal plotting as an aid to faunal analysis.

(3) That in the collection, analysis, and comparison of faunas, the following causes of failure have to be considered: Stratal, Depositional, Faunal, Dispersal, Exposure, Collection, Arrangement, Nomenclature, Fossilization, Preservation, Extraction, Zonalization, Publication; but several of these are not applicable to results derived from the investigation of limited areas.

(4) The evidence appears not only to support the conclusions of the author's former paper, but to show that in certain cases a fuller sequence of faunal episodes may be required.

(5) The fauna of small Ammonites in these Liassic beds, especially that of small *Schlotheimia* at Gloucester, suggests comparison with the faunas of Hierlatz and Spezia. The use of technical terms for different sizes of organisms, especially for small forms, is briefly illustrated.

(6) It is suggested that the strata and faunas of these Continental

localities are not so exceptional as they appear to be at first sight; and that English localities may be studied with advantage, in comparison with and explanation of the features of these Continental deposits.

(7) It is found that the preserved strata of the Gloucestershire–Worcestershire Lias under consideration happen in the main to be deposits of dates when the living Ammonites were rather small; while there is faunal failure and presumably stratal failure at the times when large Ammonites flourished. The converse phenomena are mainly illustrated by North Somerset deposits.

(8) The times when large and small Ammonites lived appear to follow one another like waves, illustrated even in a short table of Liassic deposits.

(9) As a result of the investigations connected with this paper it seems to be advisable, for recording purposes at any rate, to make further subdivisions in the scheme set forth in the author's former paper.

Edinburgh Geological Society.

November 19, 1919.—Mr. E. B. Bailey, M.C., B.A., F.G.S., President, in the chair.

1. "Notice of a Shrimp-bearing Limestone in the Calciferous Sandstone Series near Granton." By D. Tait, H.M. Geological Survey.

This is a new fossiliferous locality, which is exposed between tide-marks near Muirhouse, about midway between Cramond and Granton. The chief feature of this bed lies in the remarkable abundance of fossil shrimps which it contains, some of which may be new species. It is 18 inches thick, but is not a solid bed. It is composed of thin bands of limestone with partings of shale. It varies in thickness, and the individual bands, which are finely laminated, have minutely wrinkled surfaces and shrinkage cracks due to drying.

What is probably the same band is exposed 4 feet above the sandstone of Granton (Sea) Quarry, and again in Granton (Land) Quarry. The horizon of this band is, therefore, low down in the Granton Sandstone Series.

The fossils obtained from the limestone to this date are *Orthoceras*, *Nautilus*, *Estheria*, at least three species of shrimps, and the fishes *Rhadinichthys brevis* Traq. and *Eurynotus crenatus* Agassiz. The fishes were determined by Dr. Smith Woodward of the British Museum.

The lithological description of this bed at Granton, though it is peculiar, applies exactly also to the well-known shrimp limestone at Cheese Bay near Gullane; this and the similarity of their fossil contents tempts one to correlate them with each other. But Dr. Peach says the species of shrimps found in the Granton Bed are

different from those found at Gullane, and the Gullane Bed has been placed on the horizon of the Wardie Shales, while the Granton Bed is certainly in the Granton Sandstone Series immediately below.

2. "Note on a Find of Manganese Ore in Dalroy Burn, a Tributary of the River Nairn, Inverness." By Thomas Wallace, Inverness.

Mr. Wallace gives a general description of the district, illustrated by a map and section, showing the positions in which manganese ore was found. The chief locality is in the burn near the farm of Dalroy. The ore is there found as a band of possibly 3 feet in thickness, lying immediately under the Old Red Sandstone Conglomerate, and resting on the Gneiss below. The rock contains 30 per cent manganese oxide. Besides the ore in situ, many fragments were found in the burn, and also in the fields and at Clara Schoolhouse to the west.

3. "Exhibition of the Rhomb-Porphyry Boulder from Portsoy, Banffshire." By H. H. Read, H.M. Geological Survey.

This boulder of typical rhomb-porphyry was found between tide-marks in a cove about 50 yards west of Portsoy Gasworks. From the direction of ice-flow in Banffshire it was concluded that transport by Scandinavian ice was extremely unlikely. The possibility of transport by floating ice calved from the main Scandinavian ice front, during a period in which a narrow reach of open water lay between the Scandinavian and Scottish ice-sheets, was suggested, but the equal possibility of human transport as ship's ballast was also admitted.

December 17, 1919.—Mr. E. B. Bailey, M.C., B.A., F.G.S, President, in the chair.

"The Ayrshire Bauxitic Clay." By G. V. Wilson, B.Sc., F.G.S.

The high refractory character of the Ayrshire Bauxitic Clay was discovered early in 1916. A sample previously collected by Mr. E. M. Anderson from the exposure on Saltcoats shore had been analysed with the hope that the rock might be a bauxite. The result of this analysis showed that the material was rich in alumina, but mainly in a combined state, and so not available for use in the manufacture of aluminium. On consideration, it seemed possible that a rock containing such a high percentage of alumina as 47 per cent might possibly be of use as a refractory, and a small specimen from the locality was sent to Dr. Mellor, of Stoke-on-Trent, by Mr. W. Douglas, of Kilwinning. A test made on this sample gave the unexpectedly high refractory quality of over Seger cone 35 (1770° C.).

About the same time the late Dr. C. T. Clough was working on beds of similar age and character near Kilmarnock. He had specimens collected, and bore the expense of a series of tests by Dr. Mellor. The results, however, showed that the samples taken were not nearly so refractory as the material from Saltcoats.

The clay occurs at the top of the Millstone Grit Series, which in North Ayrshire consists mainly of a suite of basic lava-flows, with occasional interbedded fireclays, or of ganister-like sandstones. The lava series varies from 5 to 70 fathoms in thickness, and usually rests on another fireclay, "the Monkcastle Clay," which is not bauxitic.

The upper members of the lava series are often much decomposed, and often pass almost insensibly upward either into beds of poor ironstone or of bauxitic clay.

The clay varies in colour from almost white, through shades of grey, pink, yellow, or brown, to jet black; in hardness from that of a compact limestone to a faky blaes; and in texture from a compact, practically non-porous rock, with a conchoidal fracture, to an almost normal high-grade fireclay; but as yet it has never been met with in anything approaching to a plastic condition.

In some cases it is seen to be a distinct and separate deposit, but in others it appears to represent a metasomatic replacement of a pre-existing rock. Many of the detrital samples show a beautiful development of oolitic structure, which in the main appears to be due to the rolling about of small fragments (sometimes even of broken oolites) on the bottom of a shallow pool of water, which was capable of depositing aluminous material. In a few cases a somewhat similar structure has been developed by concretionary action.

The alumina content varies from 26 per cent to 52 per cent; and in varieties containing more than 39 per cent (i.e. the amount of Al_2O_3 in kaolin), practically all the silica is in the combined state as that material. The mineralogical nature of any excess alumina which might be present has not as yet been determined.

In many ways the bauxitic clay is similar to bauxite, but differs from it in that the alumina is mainly in a combined form and not free. There can be little doubt, however, that the two materials have similar origins, and it appears likely that the close of the Millstone Grit period in North Ayrshire took place under damp tropical conditions; with the result that the land surface of the lava-flows was subjected to a peculiar type of decomposition known as bauxitization or lateritization, which in this case seems to have been accompanied by reducing conditions, brought about by the decay of large quantities of vegetable matter, producing such gases as carbon dioxide and marsh gas, and thus causing the iron in the minerals present in the basalts to be reduced to a soluble ferrous condition, and thus removable by percolating waters. The alumina also seems to have gone into solution, and from the absence of any form of free silica in the deposit it appears possible that the two were combined, forming a soluble hydrous silicate of alumina, which was capable of depositing kaolin and free alumina.

January 21, 1920.—Mr. E. B. Bailey, M.C., B.A., F.G.S., President, in the Chair.

1. "Evidence of the Retreat of an Ice-sheet to the South-East of Edinburgh." By D. Anderson, M.A.

Mr. Anderson referred to the work of Professor Kendall and E. B. Bailey on the glacial channels in East Lothian, the principle of which was that of marginal drainage along the edge of a retreating ice-sheet. Mr. Anderson was led to look for similar evidence in Mid-lothian. He then described the area which he had surveyed, which consisted of two ridges and the three valleys or stream-courses by which these were marked out. The first is the Liberton–Craigmillar Ridge and the second that of Gilmerton; the stream-courses being those of the Braid Burn, the Burdiehouse Burn, and, more remotely, the North Esk. After describing the main surface features of the district by reference to the map, and an allusion to the contour of the main roads which cross the ridges in a south-easterly direction from Edinburgh, he pointed out the geological structure of the Liberton Ridge as belonging to the Upper Old Red Sandstone System, while the Gilmerton Ridge consisted of the coal and limestone series of the Carboniferous. The series of glacial channels crossing the ridges were then described. A well-marked one to the south-west is the Longloan Channel, so named from a place which stands on its west edge. The height here is 450 feet, consequently when the cutting began the impounding ice-mass must have stood somewhat higher, and since Blackford Hill, the Braids, Craiglockhart Hill, and Corstorphine Hill all reach 500 feet, these heights may have risen like low islands above the surface of the ice-lobe, somewhat back from its edge. The contour of the Longloan Channel, as well as that of the others, was indicated by sections kindly prepared by Mr. Mathieson of the Ordnance Survey from measurements taken with this special end in view. The depth here was 33 feet, and the width 303 feet. Some four more channels on this ridge were similarly described, the direction in which they were taken being from south-west to north-east. After having referred to certain other glacial phenomena on the Gilmerton Ridge in connexion with the channels, he concluded by referring to one which crosses the Liberton–Craigmillar height just at the place where this is crossed by the Old Dalkeith Road. The lobe of the retreating ice-sheet, which was the cause of the glacial channels described, probably occupied the bed of the present Forth and constituted the impounding barrier at the different heights; and was, of course, the mere shrunken remnant of a vast ice-sheet that had once enveloped the whole country.

2. "The Principles that regulate the Distribution of Particles of Heavy Minerals in Sedimentary Rocks, as illustrated by the Sandstones of the North-East of Scotland." By Dr. Wm. Mackie, M.A. Communicated by Dr. R. Campbell.

Such characters as size, specific gravity, chemical stability, and solubility all influence transportation and subsequent preservation of the mineral grains which go to form sediments. The manner of disintegration of the parent rock is of importance in determining the initial size of grains derived from it. The agent of transport, whether wind or water, takes charge of the loose grains, and sorts or mixes, preserves or destroys, according to its particular attributes of speed, temperature, and composition. Solution after deposition may sooner or later remove the far-travelled remnant. These and other principles were passed in review. Finally, a most interesting discovery was announced. All the way from Sutherlandshire and the Orkney Isles, in the north, to Yorkshire, in the south, sandstones and grits, ranging in age from Pre-Cambrian to Triassic, are apt to yield deep purple-coloured zircon in beautifully rounded grains; and this zircon has almost certainly been derived from some area lying outside of Britain.

CORRESPONDENCE.

THE AMMONITE SIPHUNCLE.

SIR,—In his interesting paper on the "Ammonite Siphuncle" in last month's GEOLOGICAL MAGAZINE, Dr. A. E. Trueman rejects my suggestion (adapted after Pictet, etc.) that *a* (not *the*) function of the siphuncle in *Nautilus* was to afford a means of attachment of the animal to its shell. I would gladly welcome a theory that explains all the facts (which my suggestion does not do), but, unfortunately, Dr. Trueman does not offer a better explanation. He considers as more reasonable, however, the opinion of Drs. Foord and Woodward, who had suggested that the siphuncle was "of more importance in the young, perhaps then serving for attachment . . ." Thus, it may be attachment after all, and the objections that I would adduce against my own explanation, Dr. Trueman does not mention, namely, (1) that histologically the siphuncle of *Nautilus* is not a ligament, and (2) that the concentric muscle-lines indicate a gradual shifting of the shell-muscles during growth, concurrently with the secretion of gas. But, while perfectly willing to admit that in some primitive Nautiloids and also in the young of Ammonoidea (which then had simple septa) the evidence of attachment is, perhaps, stronger, I do not think that we are justified in assuming, as Dr. Woodward did, that the function of the siphuncle is performed, in the adult *Nautilus*, by the shell-muscles, as though these structures were not present in the young. Nor is there any evidence that the siphuncle is of less functional importance in the recent *Nautilus* than in a homœomorphous Silurian shell, or again in a Cretaceous Ammonite than in a Devonian Goniatite.

My contention was that during a forward move of the shell-muscles (the peculiarly pitted appearance of the scars in some

fossil forms suggests a more secure attachment than in the living *Nautilus*) some additional means of attachment was useful, and that this was supplied by (but not the only function of) the penetrating fibres of the folded margin in Ammonoids and the siphuncle in *Nautilus*. Since the animals with severed siphuncle mentioned by Willey were attached to their body-chambers by means of the shell-muscles (Willey performed the operation at the base of the body-chamber, behind the annulus) there was, of course, no danger of the animals falling away from the shells. Truncation of the septate portion is not uncommon in fossil forms, and in some *Discoceras* (probably on adaptation to a purely crawling mode of life) all the cameræ were cast off and the shell of the adult (and not till then propagating) animal consisting of the body-chamber only. This merely proves that there was no further formation of septa, and the shell-muscles became permanently attached to the shell-wall and held the animal fast, but it is not evidence against my view.

On the other hand, it could be argued that owing to its constriction at the septal necks, the siphuncle of even a truncated *Protobactrites* or of an *Amphoreopsis* (with only a few cameræ) might have been sufficient for the purpose of attachment. Only here it must be admitted that if this notching of the siphuncular tube is looked upon as a strengthening feature for such attaching purposes, then a similar function must also be assumed for Ammonoidea. In some large sections before me (*Parkinsonia dorsetensis*, *Phylloceras heterophyllum*) this constriction at the septal neck is more apparent than in the (dried) shells of the recent *Nautilus*. On the other hand, inflation of the endosiphotube (between successive endosiphosheaths) and of the ectosiphuncle (between the septa) is found in many fossil *Nautili* (I am not referring to the actiniform siphuncular structures), and the separation of these from the cameræ by either thick mineral deposits or by continuous septal necks does not favour an assumption of gas-secretion by the vascular siphuncle.

My opinion certainly was not based on the interesting, if unscientific, account quoted by E. A. Smith. A reference to this was given merely to show how the shell-muscles in the living *Nautilus* became detached. But the origin of the siphuncle as a constriction of the viscera, and the various structures in the multitudinous developments of the order Nautiloidea, especially the more primitive forms (*Piloceras* and the Proteroforms of the *Cameroceras–Vaginoceras* series) seemed to me most instructive, as also the transitions from the endosiphuncular structures to the later ectosiphuncle of e.g. *Baltoceras*, which genus Hyatt placed as the first of his family Orthoceratidæ. I collected a number of very interesting Lower Ordovician Cephalopoda in Newfoundland some seven years ago, but their description is delayed because it entails a revision of the classification of the whole order Nautiloidea. I may also mention that the blackness of the outer coat of the siphuncle in *Piloceras* (the specimens are preserved in a dolomite, exactly like